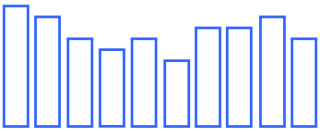
LUND UNIVERSITY
FACULTY OF ENGINEERING

Process oriented measurements and improvements

- An analysis of the OFCE-process at Tetra Pak BU DBF



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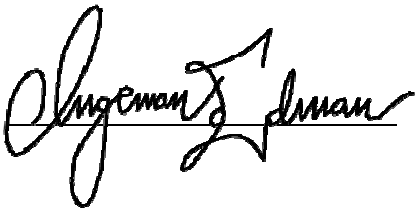
PREFACE

Process orientation, measuring and improvement work are all important concepts in a contemporary business environment. To be able to study how these are practically implemented in a world market leading company has been both a great experience and a great challenge. We hope that the reader will be able to grasp the difficulties that exist related to the above mentioned topics and learn something from our efforts.

The content of this report would not have existed without all the people that generously took time from their busy schedules to share their thoughts and answer our questions. Spending time at Tetra Pak has been a pleasure, and we hereby express our sincerest gratitude towards everybody who has helped us along the way. Special thanks go to our mentor Leif Nilsson who gave us the opportunity to conduct this master thesis and who supported us and challenged us throughout the whole project. Another person who has had great impact on the final results is our supervisor Dag Näslund at Lund University, Faculty of Engineering. His guidance has greatly influenced our work and, we believe, contributed to better results. We thus would like to thank him as well. Last but not least we would like to thank our opponent Nina Åxman, whose comments and ideas have helped to improve the readability of this report.

Lund, June 2009



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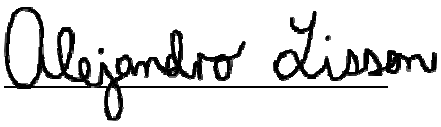

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ABSTRACT

Title Process oriented measurements and improvements
- An analysis of the OFCE-process at Tetra Pak BU DBF

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Background During the last decades markets have become increasingly competitive due to globalization. This has forced companies to become process oriented to provide more value to the customer by focusing on the efficiency and effectiveness of the daily business. An important step in this work is to introduce a measurement system that can help to monitor performance and determine improvement areas.

Tetra Pak BU DBF, a company within Tetra Pak, has during the last years become process oriented and are currently working with applying a *lean philosophy*. To overview this they have introduced a measurement system called 'New Milestones' in their order fulfilment process (OFCE). The system focuses on measuring the internal delivery accuracy, and the results from the last two years indicate issues in the process. The delivery accuracy target towards external customers is still met, but only through the use of overtime and excessive resources.

Purpose The main purpose of this thesis is to conduct a critical analysis of the order fulfilment process (OFCE) at Tetra Pak BU DBF as well as of its measurement system in order to identify improvement possibilities.

Method The study will be conducted as a case study, focusing on a single case. Triangulation between qualitative and quantitative data is used in order to increase the credibility of the thesis. The main source of information is interviews, which is complemented with operational data and observations.

Conclusions

Deviations from the process descriptions

In general the process design seems to be followed and only a couple of deviations from the directives were identified. On the other hand there are strong reasons to believe that these deviations are causing problems in the handling of the orders. All deviations from process directives should be eliminated to be able to observe the true process performance.

Delays throughout the process

The clarification of orders takes too much time and delays later stages of the process. At the same time, the engineering is suffering from delays due to revisions of the bill of materials (BoM). To reduce delays in these phases, feedback on the reasons of the delays should be collected. In relation with purchasing of components problems are related to late deliveries from the suppliers. To solve this problem, dialogue, incitements and fines could be used. In the testing of the produced equipment most of the interruptions are related to problems originated in the previous phases of the process. Here feedback is available but it is not always used for driving corrective actions. In general better feedback systems are needed.

Evaluation of the measurement system

The OFCE-process has, as mentioned, some issues but the bad results indicated by the 'New Milestones' are also related to problems with the measurement system itself. One issue is that the 'Order confirmation Milestone' does not take into consideration that some orders needs additional time to be clarified. Another issue identified was that the Milestones measuring the ordering of components are not measure what was intended. The results are therefore not indicating the real process performance and divert attention from a problem area. In general the Milestones need to be reviewed both in terms of design and measuring.

Keywords Process, Process management, Performance measurement systems, Lean, WCM, Order fulfilment, Tetra Pak, case study, analysis

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1 INTRODUCTION

This chapter presents the background of the thesis, its purpose and objectives. After reading this chapter the reader should be able to understand the selection of material presented in each of the following chapters.

1.1 Background

Companies have throughout time tried their best to satisfy the potential customer's needs. To do this they have created and developed ways to provide the customers with the right kind of products or services. Towards the end of the 20th century the conditions for most companies have changed. Markets have become increasingly competitive due to globalization, resources have become scarcer, and economies fluctuate more (Scherrer-Rathje et al., 2008). With the number of products available, customer expectations have at the same time steadily increased in respect to quality, service and price; forcing the companies to look for new creative solutions to satisfy them (Juran Institute Inc., 2008). Major innovations are usually a good source to gain competitive advantage, but since these rarely occur and since the advantage often is time limited, focus must also be on efficiency and effectiveness in the daily business (Greve, 2009). During the last decades companies have started to become *process oriented* in order to provide more value to the customer through better execution of operations (Hammer, 2002, Hammer, 2007i). Today, cost reduction and continuous improvements are in many industries necessary for a company to stay competitive (Polischuk, 2009).

Becoming process oriented is not something done over a night and without the proper knowledge and tools there is a great risk of falling short of the goal. An important step is to introduce a measurement system that supports this way of thinking (Ljungberg et al., 2001). If this is not done there is great a risk that every department or function will optimize their work, at the cost of other departments and the company as a whole (Ljungberg et al., 2001, Rummler et. al, 1991). Measuring is further necessary to determine improvement areas and to enable work with continuous improvements (Ljungberg et al., 2001). Designing a good measurement system is difficult though since there are multiple characteristics that need to be considered (Bourne et al, 1997).

Tetra Pak is one of the worlds leading manufacturer of packaging material and processing solutions for food and has been successful since its start in 1951. Tetra Pak started the work with becoming process orientated in 2001 (Hammer, 2007i) and are currently working with the implementation of *Lean Production* (though called World Class Manufacturing).

Tetra Pak BU DBF produces processing equipment for dairy products, beverages (e.g. soft drinks and fruit juices) and prepared food (e.g. soups and children's food). In order to survey the lean transformation project in their order fulfilment process (OFCE) a performance measurement system called "New Milestones" has been introduced. It monitors the internal delivery accuracy by measuring how many of the orders are following their time schedule throughout the process. The results of the measuring from the past two years show that time schedules have not been followed to a satisfactory degree, despite that the problems have been highlighted and actions have been taken. The importance of keeping the scheduled time is related to the delivery accuracy, which the company wishes to

maintain at 95 % towards the external costumer. This is achieved today, but only with the use of overtime and excessive resources in late stages of the process.

1.2 Purpose

This master thesis will be constituted by a critical analysis of the OFCE (Order Fulfilment Capital Equipment) process as well as of its measurement system in order to identify improvement areas. The OFCE process in Lund is going to be used as benchmark for Tetra Pak's plants in Greenwood, USA and Shanghai, China and thus it is important that first identify and eliminate issues here, both in process execution and the measuring of it.

1.3 Problem discussion

Based on the situation described above three distinct problems can be identified within the OFCE-process and the measuring of it at present time.

- Are there any deviations from the documented process description in how the daily work is carried out? If this is the case, are these deviations causing problems?

- The Milestones are not met to a sufficient degree and the causes behind the delays are not known. What are the causes and how could they be dealt with?

- The results of the measuring system tell a tale of an inefficient process. Could these results partly be a consequence of an inefficient and complicated measuring system? Could the measuring system be improved to better serve its purpose?

1.4 Objectives

Based on the problems indentified above, three objectives of the thesis can be formulated.

- The first objective of the thesis is to establish a good understanding of the process and its characteristics. A description should be presented in the thesis report.

- The second objective is to analyze the process and identify improvement possibilities.

- The third objective is to describe the measurement system and its connections to the process. The system should then be analyzed and improvements should be suggested.

The presented results should be specific enough to be applicable in BU DBF's process development, but also have enough general elements to enable benchmarking for other parts of the organization.

1.5 Delimitations and focus

Tetra Pak BU DBF has worked hard, and continues to do so, with process orientation and development. This thesis is focusing on the OFCE-process which starts with orders being received at the back office and ends with the product being delivered and tested to performance at the customer's site. To analyze the whole process would be a too big a task to perform within the time frame of the thesis. The layout of the assembly workshop has recently undergone some large changes and new routines have not yet been given time to settle in. For these reasons the thesis will leave out the activities performed in the production phase. Issues related to the production activities and the interface with other phases will be treated though.

BU DBF is divided into three product groups; Dairy, Beverage and Prepared Food. Focus of this thesis will lie on the two prior, since Prepared Food handles fewer orders and work in a somewhat different way compared to Dairy and Beverage.

Orders in the OFCE-process can be of different complexity. M1 orders are fully standardized, M2 orders involve selection of options but no engineering while M3 orders involve customization to customer needs. Since most orders are of type M3, the thesis will primarily focus on the processing of these orders.

1.6 The target group

The target group of this report is in part the management team at Tetra Pak BU DBF responsible for the OFCE-process. It could also be of interest to personnel working within the process, who wish to deepen their understanding of the current state of it and its improvement possibilities.

Other target groups are other employees within Tetra Pak and any member of the public interested in learning more about process orientation and measurement systems in an organization and the possibilities/hardships related to these.

1.7 Report structure

The report is divided into seven chapters all with clearly defined and delimitated purpose and content.

Chapter 1: Introduction
The Introduction chapter presents a short background to the thesis, its purpose and goals, its delimitations and focus, and its target group. The purpose of the chapter is to give the reader a basic understanding of the case and the goals of the thesis, which will help in the understanding of the selection of material presented in the following chapters.

Chapter 2: Methodology
In the Methodology chapter relevant concepts are described together with their applications in the thesis work. By introducing several viewpoints and important terms the reader is given the opportunity to understand the reasoning behind the choice of methodology used in the thesis.

Chapter 3: Theory
The theory chapter presents some of the most important insights published by researchers within the areas of focus of the thesis. The first subchapter introduces the main concepts and tools of lean production. The second subchapter introduces background and theory related to process orientation. The third and last subchapter defines important characteristics of a good measurement system, and further introduces some useful frameworks that can be applied when working with evaluating and implementing it.

Chapter 4: Empirical data - Descriptions
This chapter, the first of two chapters with empirical data, introduces in turn Tetra Pak's history and organization, the OFCE-process, the New Milestones and some WCM (World Class Manufacturing) initiatives. The level of the description is aimed to be detailed enough to understand the issues, but at the same time comprehensive for readers with no previous knowledge of Tetra Pak.

Chapter 5: Empirical data – Problems and improvement areas
This chapter, the second of the chapters with empirical data, introduces the problems with the process and the measurement system respectively. The reader should after reading Chapter 4 have the basic insights necessary for understanding the issues presented in this chapter.

Chapter 6: Analysis
The Analysis chapter evaluates the observations presented in the previous chapter and in some cases evolves them further. Whenever possible the theoretical framework is applied to connect the findings to their equivalents in previous research. When possible the issues are connected to possible causes and recommendations on what actions could be taken to reduce the effects of these. The last subchapter focuses on trying to generalize the insights of the specific case.

Chapter 7: Conclusions
The Conclusions chapter summarizes and presents the most valuable results of the analysis together with recommendations on what should be done next. The second subchapter focuses the credibility of the findings.

2 METHODOLOGY

In order to produce reliable scientific results, the researcher needs to make certain methodological considerations. In this chapter the reader is given an overview of some important methodological concepts and their connection to the thesis work.

2.1 Epistemology

Epistemology is a branch of philosophy that deals with questions related to knowledge and more precise to its methods, validity, and scope. This chapter will introduce some of the main views of knowledge and connect them to the thesis.

2.1.1 Scientific viewpoints

Depending on the researchers view of knowledge as such, the aims and goals of the research may differ significantly. Björklund et al. (2003) presents three different points of view in the matter:

Analytical viewpoint
With this viewpoint the researcher strives to describe the reality as completely and objectively as possible. All subjective views/opinions are disregarded from and the knowledge is considered as independent of the observer. The researcher aims to find the relation between cause and effect and the reality is seen upon as an entity built up by smaller parts, in which the sum of the parts constitutes the whole. (Björklund et al., 2003)

Systems viewpoint
The researcher aims to describe the reality objectively, but the sum of the parts of reality are said to constitute less than the whole. The systemic approach puts great weight on synergies and states that the relations between parts are as important as the parts themselves. The researcher studies the relations between different parts of the system in effort to understand the underlying reasons for certain observed behaviour. (Björklund et al., 2003)

The actor's viewpoint
This viewpoint emphasises on reality being a social construction that is affected by and in turn affects the human living within it. The description of the reality thus depends on the observer, her/his experiences and actions. (Björklund et al., 2003)

2.1.2 Scientific philosophies

Among the existing scientific philosophies three are relevant in the context of this thesis, positivism, systems theory and hermeneutics.

Positivism
One of the fundamental theses within the philosophy of positivism is the "thesis of verification". Any scientific thesis could only be considered having meaning if it can be verified with empirical studies. Accepting this thesis means excluding everything that cannot be tested with empirical studies, such as feelings, values etc. from the scientific sphere. (Wallén, 1996)

Some characteristics of positivism are presented in Table 2-1 below.

Table 2-1 Characteristics of positivism

Characteristics of positivism (Wallén, 1996)
Scientific rationality - A fundamental characteristic of positivism is the belief in scientific rationality.
Empirical verifications - The knowledge should be empirically verified. Any assumptions and assessments should be replaced by measurements.
Relation between causes and effects - All explanations should be given in the form of cause and effect and knowledge should be presented as relations regulated by laws.

Systems theory

A wide definition of a *system* is a group of objects that interact with each other. The system as a whole has properties that differ from those of the different parts. A narrower definition of a system is that the interactions and structure of the system support a function. The system boundaries are determined by the function. (Wallén, 1996)

Some characteristics of systems theory are presented in Table 2-2 below.

Table 2-2 Characteristics of systems theory

Characteristics of systems theory (Wallén, 1996)
System delimitations - What is the function of the system and how is it delimited from its surroundings?
System construction - Which are the parts that constitute the system and how are they arranged? What happens when the system level is shifted?
Flows - Studies should be conducted of the different flows within the system and between the system and its surrounding.

The systems theory has its strengths compared to positivism when simple relations between cause and effect cannot be identified. Systems theory better explains situations where there are multiple, concurrent causes which leads to a multiplying effect or synergies. A major area of application of the systems theory is within organizing and planning of operations. In both models the objects of study are processes and an important aspect is the interaction between parts of the system as well as its structures.

Hermeneutics

Hermeneutics is a research philosophy that involves the interpretation of phenomena. The "interpretation" could denote "to follow and identify a custom/practice or tradition" and hermeneutics should in most cases be seen as a complement to positivism. (Wallén, 1996)

Some characteristics of hermeneutics are presented in Table 2-3.

Table 2-3 Characteristics of hermeneutics

Characteristics of hermeneutics (Wallén, 1996)
Interpretation - Hermeneutics is about the interpretation of the meaning in texts, symbols, actions, experiences etc.
Different perspectives - When interpreting, one shifts between a partial and holistic perspective. The contradictions between the parts and the whole are given special attention. Every new part that is examined can bring a different view of the whole or of another previously studied part.
Context - All interpretation has to be made in relation to a context. As an interpreter one must thus recognize and acknowledge the context in which a text/an object is created.

2.1.3 Epistemology of the thesis

The study takes a systems viewpoint and thus to large extent is bound by the systems theory assumptions. The OFCE-process consists of multiple parts which cannot be considered as independent entities, but must always be seen in relation to other parts. Even though only one part is studied at the time, the findings always have to be reconnected to the holistic view. Most of the empirical material will be the experience of employees and managers in the process and thus the hermeneutics theory is also relevant in this context. From positivism the thoughts around scientific rationality and empirical verifications are considered.

2.2 Research methodology and credibility

When conducting a study it is important to be aware of and follow accepted research methodology in order for the results to be credible.

2.2.1 Research methodology

When working with academic research one often wanders between different levels of abstraction where the extremes are theory (general) and empirical data (concrete). (Björklund et al., 2003)

Induction

Induction is an approach to research where you start with reality and try to discover patterns that can be summarized in models and theories. When it comes to induction an area could be studied without any preparatory reading of theory. Instead the theory is formulated with basis in the empirical data, which should be collected unconditionally (Wallén, 1996, Björklund et al., 2003)

Deduction

Deduction consists of making predictions of what the empirical data collection will give with basis in theory. This approach demands that the researcher knows a lot about the phenomenon being studied (Wallén, 1996). The next step is to try to get confirmation of

the theories in the empirical data. Conclusions about separate events are thus drawn with basis in the existing theories. (Björklund et al., 2003)

Abduction
When wandering occurs between the two levels of abstraction, the term abduction is used (Björklund et al. 2003). Abduction tries to establish the causes of certain effects without directly being able to manipulate these. The problem with this approach is that it is hard to find exclusive relations. The basis is a probable relationship from which one can draw conclusions based on exclusion principles, and then complement with tests. (Wallén, 1996)

2.2.2 The research methodology of thesis

The research methodology used is mainly deduction since the study tries to establish which theories could be applied to the empirical material. An element of abduction exists since changes cannot be made to the process in order to verify any cause-effect relations.

2.2.3 Credibility

Within scientific literature and research there are three measurements related to credibility that always should be considered, namely validity, reliability and objectivity. (Björklund et al., 2003)

Validity
Validity describes to which extent metrics are measuring what was intended. Do the conclusions drawn make any sense? (Bryman et al., 2005)

Validity can be divided into different groups (see Table 2-4 below).

Table 2-4 Different forms of validity

Different forms of validity (Bryman et al., 2005)
Conceptual validity (Theoretical validity) – This type of validity describes to which extent the measurements actually measures what is intended.
Internal validity - This type of validity deals with the question whether a conclusion that withholds a causal relationship between two or more variables is valid or not. If a conclusion is drawn that x causes y, how can one be sure that this relationship is true and not of pseudo type (meaning that y is caused by other factors)?
External validity – This type of validity deals with the question whether the result of the research could be generalized outside of the specific research context. It could be a question of how the participants in the research were selected.

The validity can be increased by the application of multiple perspectives, e.g. through triangulation. When using interviews and surveys the validity increases when questions are clear and not biased (Björklund et al., 2003).

Reliability
Reliability reflects on to what extent results repeat themselves if the study is redone. Low reliability indicates that the results are biased due to random or temporary events (Bryman et al, 2005). Especially quantitative researchers need to think in terms of reliability and can increase it through the use of control questions and triangulation (see below) (Björklund et al., 2003).

Objectivity
Objectivity deals with the question to what extent the values (of the researcher) affect the results. A good objectivity is secured through a clear presentation and motivation of the choices made in the study. When referring to sources it is important to make sure that there are no factual errors, that the selection of facts is not biased, and to limit the use of emotive words. (Björklund et al., 2003)

Triangulation
Triangulation means using many (different) methods to investigate a single event, and thereby get a multiple-perspective research result. Two or more methods are used for the same purpose. (Björklund et al., 2003)

Three different types of triangulation are presented in Table 2-5 below.

Table 2-5 Examples of triangulation

Examples of triangulation (Björklund et al., 2003)
Data triangulation – Multiple data sources are used, e.g. books, respondents.
Researcher triangulation – Multiple researchers do the same analysis.
Theoretical triangulation – Multiple theories are applied to the same data set.

2.2.4 Credibility of the thesis

The validity of the thesis has been given a great deal of consideration. By triangulating different sources of information an attempt is made to increase the validity, and the 'conceptual' as well as the 'external validity' is expected to be high. Statements on causalities will be treated carefully in order not to lower the internal validity. The timeframe of thesis is too short to draw any greater conclusions on the performance of the process.

The reliability of the thesis is rather low considering that the object of study (the process and its participants) is dynamic and constantly changing. The study should instead be used as background and basis for new studies and new findings can be compared to the results presented in this thesis.

By verbalising their initial standpoints and question each others viewpoints, the authors attempt to secure high objectivity.

2.3 *Research strategies and design*

The question of whether there in modern research is any difference between qualitative and quantitative studies is debated. Some point out that the difference may be "false", and others that it is both more evident and important than ever. (Bryman et al., 2005)

2.3.1 Quantitative studies

Some characteristics of quantitative research are presented in Table 2-6 below.

Table 2-6 Characteristics of quantitative research

Characteristics of quantitative research
▪ Quantitative studies deals with information that can be measured or valued in numerical terms (Björklund et al., 2003). ▪ Has a deductive view of the relations between theory and practical research. The emphasis is on testing theories. (Bryman et al., 2005) ▪ Is thoroughly based on scientific norms, especially when it comes to positivism. (Bryman et al., 2005)

Some critique has been presented towards the quantitative approach, especially in studies of social contexts. In quantitative research there is often no distinguishing between humans/social institutions and nature. (Bryman et al, 2005). It has also been pointed out that the measuring gives a false 'image of precision and accuracy'. Other points of critique towards the use of quantitative methods are that they cloud up the results by applying too advanced methods, that they often use of too large sample sizes or that it is difficult to understand and interpret the results (Frankel et. al., 2005). Especially when it comes down to the analysis of the social relations quantitative methods lead to a static view of the social life without any consideration taken to how people live their lives. (Bryman et al., 2005)

2.3.2 Qualitative studies

Some characteristics of qualitative research are presented in Table 2-7 below.

Table 2-7 Characteristics of qualitative research

Characteristics of qualitative research
▪ Qualitative studies are used when the researcher wants to create a deeper knowledge for a specific subject, action or situation. The possibility of generalisation of the results is inferior to results discovered in quantitative studies. (Björklund et al., 2003) ▪ The focus is on an inductive view of the relation between theory and research, where the emphasis is on generating theory. (Bryman et al., 2005) ▪ Distances itself from the norms and approaches of the scientific model (especially the positivism) and puts emphasis on the participants' interpretation of their social reality. (Bryman et al., 2005)

Qualitative has a weakness in being the object of questionable objectivity and it can easier be biased than a quantitative approach. The view of the more traditional researchers is that qualitative studies can and should be used to get familiar with the setting before starting up a quantitative study. (Frankel et. al, 2005)

2.3.3 Type of studies

Apart from categorizing studies as quantitative or qualitative, they can be divided into four different types depending on their objectives. The four main types of studies can be seen in Table 2-8 below.

Table 2-8 Types of studies

Types of studies (Björklund et al., 2003)
Explorative – This type is used when the knowledge within the area of interest is limited and the aim of the research/study is to develop a fundamental insight.
Descriptive – This type is used when fundamental insight already exists and the aim is to describe relations within the area, but not to explain them.
Explanative – This type is used when one strives to achieve a deeper knowledge by both describing and explaining the relations within the area of interest.
Normative – This type is used when a certain amount of knowledge already exists, and the aim is to present advice and possible improvements within the area of interest.

2.3.4 Research strategy employed in thesis

The thesis could be categorized as a combination of a descriptive and an explanative study. It both aims to describe how the process is conducted and to explain why certain phenomena are occurring. Most of the data used will be qualitative since this is most direct and complete source of information, but it will be complemented with quantitative data from the already conducted measuring and other internal sources. By combining qualitative and quantitative data the authors hope to be able to establish more reliable relations and increase the overall credibility of the thesis.

2.3.5 Data collection

Data used in studies can on a high level be divided into two groups, primary or secondary data. It is important for researcher to know which one of the groups is used and to understand its characteristics and the potential errors related to each group.

Primary data

Primary data is information gathered by researchers first hand and therefore specifically collected with regards to the objective of their investigation. The analyst can obtain primary data by direct observation or by interviewing people (Rabianski, 2003).

Observation – The observation is a data gathering technique that concentrates on observable facts. The observation can be of an inanimate object, an action or behaviour. When the

observation is done of an action, the inaccuracy of the measurement tends to be higher than when observing an inanimate object. Observations should not be interpreted when collected, but be reported in full to avoid losing essential information. (Rabianski, 2003)

Interviewing – Interviews can provide valuable information, although some data obtained from questioning can be inaccurate due to misunderstandings or invented answers. Another matter to consider is that the sample of people that is interview might not represent the entire population, thus possibly leading to incorrect conclusions. The attitude and actions of the interviewer can also influence the answer of the interviewee. (Rabianski, 2003)

Secondary data
Secondary data is information that was not collected by the researchers for the objective of the investigation, but by someone else for other reasons. The data could be used in other ways though and for that reason it is common to find secondary data among published sources. As secondary data often once were the primary data for other investigations, it was collected using primary data techniques. Therefore it is important for researchers to understand the problems occurring in the gathering of primary data because these rules will apply for the secondary data sources. (Rabianski, 2003)

One category of errors is related to the sample chosen. If the sample does not represent the studies population the results are not credible. The way that data is obtained is also a source of potential errors and these involve everything from misinterpretations and mistakes to missing data or a too narrow range of answer possibilities. Another category of errors relates to the handling of data, where manipulation and pollution of data, as well as conceptual error in measurement design invalidates the data obtained. A third category of errors relates to changes inconsistency in collection procedures, or updates of only certain values in a set. (Rabianski, 2003)

2.3.6 Data collection employed in thesis

The data used in the thesis will be collected primarily through interviews with people working in the process. This information will be complemented by data obtained from various documents and directly from the ERP-system. When possible the process will be observed in action. The data thus consist of both primary and secondary data, and by triangulation these are combined to form a picture of the present and previous states of the system. Caution will be taken to avoid the error categories mentioned above, but the reader should still bare them in mind when interpreting the results.

2.3.7 Research Design

Research strategy is closely related to the choice between qualitative and quantitative research. Further there are a number of tactical decisions that has to be made that regard the practical implementation of the study and the analysis of the collected data. Two terms related to the tactical decisions are ‘research design’ and ‘research method(s)’.

Research design constitutes a framework for the collection and analysis of data. The research design is the structure that guides the research in the choice and application of a certain research method. A research method is a technique for collection of data. A number of instruments/tools can be of use, such as surveys, interviews and observations. (Bryman et al., 2005)

There are five major types of research designs that will be presented below.

Experimental design
Experimental studies, especially within business administration research, are often used as a yardstick when evaluating the credibility of non-experimental research. The experiments are used to test the established casual relationships and tend to have a high internal validity. One reason to why experiments are not used in a greater extent is that they often demand a manipulation of the explanatory variable, which sometimes could be hard or impossible (e.g. the sex of a person). (Bryman et al., 2005)

Survey studies
The terms 'survey design' and 'cross-sectional' design are often used interchangeably, but the latter, more general is preferable. The *cross-sectional design* involves collecting data from more than one case at a certain time with the intention to build a set of qualitative or quantitative data with connections between two or more variables. This data are the analysed in search of patterns. The *survey design* of the other hand has is a cross-sectional design where information is collected through surveys and/or structured interviews. (Bryman et al., 2005)

Longitudinal studies
The longitudinal study is primarily used for describing changes. Because of the time and costs related to this form of research it is seldom applied. This design can be considered an augmented version of the cross-sectional design mentioned above. The main difference is that studies are conducted over a longer period of time, thus making it easier to draw valid conclusions about different phenomena. (Bryman et al., 2005)

Comparative studies
This research design compares two or more separate cases that are studied in parallel. The design holds a comparative logic that prerequisite that a deeper knowledge can be built based on comparison between multiple similar/differing cases. The design could be implemented with both a quantitative and a qualitative approach, and the data collection is based on the cross-sectional design. (Bryman et al., 2005)

Case studies
The basic case study involves a thorough investigation of a single case. Stake means that that case study research should involve the specific complexity and nature of the individual case. He further identifies issues as one of two ways of working with cases and a great source to finding the (root) problems (Stake, 1995). (Bryman et al., 2005)

2.3.8 Research design employed in the thesis

After considering the objectives of the thesis, the case study has been chosen as the general design. This will be further described in the following chapter.

2.4 Case studies

A case study is an empirical research method that investigates a contemporary event within its real-life context, especially where the boundaries between the event and the conditions around it are not evident. The case study relies on multiple sources of information as input into the analysis and benefits from the prior development of theoretical propositions as a guide through the data collection (and the analysis of it). (Yin, 1994)

Case study research is a preferred strategy when the questions "how" and "why" are of interest and can include both single and multiple-case studies. Case studies should not be considered only as "qualitative research" since they can be structured as either quantitative research or qualitative research, or even a mix of both. This is similar to research strategies like experiments and surveys where sometimes the study relies on qualitative data, instead of quantitative, as most people believe. (Yin, 1994)

2.4.1 Case study procedures

When conducting a case study there are pre-specified procedures that need to be followed (see Figure 2-1). A summary of each of these are presented below.

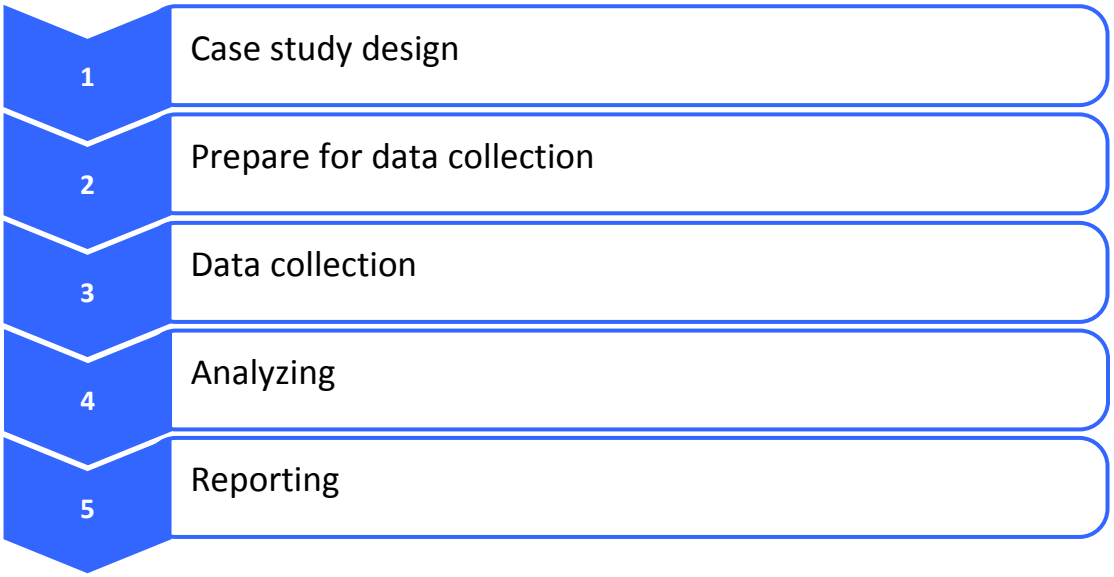

Figure 2-1 Case study procedures – five steps

1) Case study design

The design of a case study is the logic that connects the possible results from the research to the question posed at the beginning of the study. Furthermore, it connects the empirical data collected with the possible conclusions drawn at the end of the study. The design can be seen as an action plan for conducting the whole study. (Yin, 1994)

2) Preparing for data collection

Yin presents some requirements that must be met in order to be well prepared for a case study. The investigator should in advance have acquired the desired skills and training for the specific case study, he/she should also have developed a protocol and conducted a pilot case study (see Table 2-9 below). (Yin, 1994)

Table 2-9 Case study preparations

Case study preparations (Yin, 1994)
Desired skills – The skills required for performing case studies are more demanding than those required for doing an experiment or a survey. The investigators should at least have the following skills: being able to ask good question, being a good listener, be adaptive and flexible and avoid being biased by previous knowledge.
Case study protocol – The protocol contains the rules and procedures that should be followed. It helps increase the reliability of the study and also serves as a guide through the research.
Pilot case study – The pilot study is necessary because it helps the investigators to refine what data should they collect as well as the procedures they have to follow.

3) Data collection

Relevant facts can be collected from six different sources: documents, archival records, interviews, direct observation, participant observation and physical artefacts. There are three principles that should be followed while performing the data collection presented in Table 2-10 below.

Table 2-10 Case study data collection

Case study data collection (Yin, 1994)
Use multiple sources of evidence – The most important advantage of using multiple sources is that the evidence brought by different sources could converge to the same point; therefore, increasing the validity of the conclusions brought by the case study.
Create a Case Study Database – The investigator should organize and document all the data collected for the research. This will give more reliability to the case study as other investigator can go through the data of the database and verify it, instead of being limited to the data presented in the final report.
Maintain a chain of evidence – Another important aspect to increase the reliability of the research is to maintain a chain of evidence. This means the investigator should present the collected evidence and its analysis from the start of the research to the conclusions.

4) Analyzing case study evidence

This step consists of examining and categorizing the evidence to try to answer the questions posed at the beginning of the case study. All investigations should start with a general analytic strategy, prioritizing what to analyze and why. Within such strategies, four dominant analytic techniques should be used, independent of if it is a single or a multiple case study. Two of the most common is *pattern matching*, where empirical findings are

compared with predictions made prior to the data collection, and *time-series analysis* where the object of study is followed over a period of time.

5) Composing the case study report
For the writing of the report, the investigator needs to properly identify the audience of the report and develop a good compositional structure. Considerations should be given to how identities of people involved in the case should be treated and how and by whom the report should be reviewed.

2.5 *Interview technique*

A research interview is a professional conversation based on daily life. Throughout an interview the knowledge is built through the interaction between the interviewer and the interviewee, who exchange their views about a common subject of interest (Brinkmann, 2009). Stake argues that since one of the principal uses of case studies is to obtain the views of others, interviews are very well suited; "The interview is the main road to multiple realities" (Stake, 1995).

2.5.1 Structured interviews (Quantitative)

A structured interview is conducted in such a way that the interviewer asks the respondent questions based on an interview guide. The aim is to create the same context for every respondent, and thereby ensure that the answers are comparable. This can only be achieved if the responses are reactions to the same questions. Thus the interviewers must formulate the questions in an identical way and present them to the respondent in the same order. The questions are often very specific and give the respondent a couple of answer alternatives. (Bryman et al., 2005)

To come up with the right questions can be hard, but to be able to ask them in the right way, usually constitutes the biggest challenge for most researchers. The most important consideration is whether a specific question should be opened or closed. An open question gives the respondent the possibility answer freely, while the closed questions give him/her a number of alternatives to choose from. (Bryman et al., 2005)

Open questions have the advantage that the respondent can use their own words and are not forced to use the formulation of the researcher. This opens the possibility for unexpected or unusual answers – answer which the researcher never imagined possible when constructing the questions. Open questions are very well suited for exploring undocumented areas or areas where the researcher does not have previous insight. Open questions could be used when striving to come up with response alternatives. (Bryman et al., 2005)

Closed questions on the other hand have advantages when it comes to processing the answers. The procedure is easier and the results are comparable to a larger extent. The closed questions are also good at clarifying the intention to the respondent. The closed questions are easy to pose and easy to answer and at the same time as the risk of variation

becomes smaller. The limitations of closed questions are their lack of catching the spontaneity that often exists in the respondents answer. There might also be difficulties in creating mutually exclusive answers that at the same time exhausts all possibilities. (Bryman et al., 2005)

2.5.2 Semi-structured interviews (Qualitative)

Qualitative research interviews are used to understand themes from the daily life from the subject's perspective. It is similar to a daily conversation but it has a specific approach and procedures of questioning that make it a professional interview. (Brinkmann, 2009)
Interviewing is probably the most commonly used method in qualitative research, which has a lot to do with its flexibility (Bryman et al., 2005). The differences between qualitative and quantitative interviews are presented in Table 2-11 below.

Table 2-11 Differences between qualitative and quantitative interviews

Differences between qualitative and quantitative interviews (Bryman et al., 2005)
▪ The approach in qualitative interviews is usually a lot less structured and there is left a lot of room for own opinions of the persons involved in the interview. ▪ The qualitative interview focuses on the interests of the respondent rather than those of the researcher, which is the case with quantitative interviews. ▪ The qualitative interviews can diverge quite a lot from the interview guide and depending on the responses spontaneous follow-up questions could be asked. Because of this the qualitative interviews appear to be more flexible. ▪ In qualitative interviews the researcher wants exhausting answers, while quantitative interviews focus on short answer that can be coded and processed. ▪ In qualitative interviews, the respondents can be interviewed several times, while an interviewee in general only participates once in a quantitative study.

The semi-structured interview is based around a list of rather specific themes (interview guide) but the respondents are free to construct their answers. The questions can be posed in a different order than they are described in the interview guide, and questions can be amended depending of the responses. Usually the interview guide is followed though. (Bryman et al., 2005)

2.5.3 Interview techniques employed in the thesis

Since interviews were used as a mean of collecting information about the process they were of a qualitative nature, and in order to catch the interviewee's individual areas of interest they were semi-structured. Interview guides were used to in order to maintain focus.

The interviewees were selected continuously throughout the project based on the areas of interest identified when collecting information on the process and its improvement areas. For some areas multiple persons with the same role were interviewed to avoid getting a biased picture of the current state of the process.

3 THEORY

This chapter will provide a knowledge basis for the later analysis and is divided into three distinct, but interrelated parts. The first subchapter focuses on the lean philosophy, the second on process orientation and the third on performance measuring.

3.1 Lean

This subchapter will briefly touch upon the concept of lean (production) to give the reader an idea of how this philosophy is used. Tetra Pak are working actively with lean tools and philosophies, but under the name 'World Class Manufacturing' (WMC).

Key insights

- Lean philosophy is about eliminating wastes
- The seven wastes are: overproduction, waiting, transport, inappropriate processing, excess inventory, unnecessary movements, and defects
- In order for lean work to be efficient a holistic view must be applied
- Essential tools include 'Kanban', 'Kaizen', 'Poka-yoke', '5 S', '5 Why', and 'Value Stream Mapping' (VSM)

3.1.1 The seven wastes

The lean concept is originally derived from the Japanese manufacturing success or, to be more precise, from the Toyota Production System (Polischuk, 2009). In designing, engineering, producing and delivering a product that satisfies a customer needs there are basically two types of activities. The first type of activities creates value that the customer can see and appreciate while the second type of activities does not generate value visible to the customer, but are needed to complete the business transaction (Keyte et al., 2008). Lean is an effort to make organizations more competitive in the market, as it seeks to increase efficiency and reduce cost by eliminating non-value adding activities and inefficiency from the process (Näslund, 2008). This broad definition is concretised in the work aimed at eliminating *waste* in every area of production including customer relations, product design, supplier networks and factory management (Näslund, 2008). The lean production concepts has its origin in and widest application on the workshop floor, but lately the focus has been broadened to include office environments as well.

The first step in lean orientation is to identify the value flow of the organization, which is best done by using a value stream map (see subchapter below). In the value stream maps the office functions are commonly excluded which creates a fragmented and incomplete picture of the business and its processes. This can result in disregard from the fact that problems/wastes observed on the factory floor might have their origin in previous stages of the process or in its supporting processes. An important insight is that the failure to apply lean to the whole business can severely limit the positive impact of the initiatives taken on the workshop floor (Keyte et al., 2008). Waste reduction efforts could on the other hand start locally and then be extended to the whole organization and from the organization to its entire supply chain network (Scherrer-Rathje et al., 2008).

So which are these wastes that should be eliminated? A waste can in short be defined as activities that increase cost without generating value to the customer (Keyte et al., 2008). Lean authors have identified seven common main types of waste; overproduction, waiting, transport, inappropriate processing, excess inventory, unnecessary movements, and defects

(Näslund, 2008). When focus is put on an office level an eighth one could be added, unexploited creativity (Keyte et al., 2008). These are all presented in Table 3-1 below:

Table 3-1 Lean - the seven wastes in workshop and office environment.

Waste	Workshop (Hines et al., 1997)	Office (Keyte et al., 2008)
Overproduction	Leads to an excessive work-in-progress stock and long lead and storage time for the finished products. Toyota employed the pull or 'kanban' system to overcome problems related to overproduction.	Overproduction in the office could be to produce more, earlier or faster than what is needed/requested by the process step that follows.
Waiting	Occurs whenever a product is in queue or not being worked on and the reason for this is often ineffectively use of time. The ideal is to have no waiting times with a consequent faster flow of goods. Waiting time for workers should be used for value adding activities such as 'Kaizen'.	Waiting could be related to downtime of the system, the response time of the system, outstanding acknowledgement from others or information from customers.
Transport	Transport is the moving of goods. Taken to an extreme, all transport could be considered as waste and therefore a good target in the context of lean is the minimization of it. Excessive handling and transport does not add value to the product and can on the contrary cause damage to it.	Transport is mostly related to movement of paper or documents. Problems could be extensive e-mail attachments, multiple handovers and acknowledgments.
Inappropriate processing	Occurs when complex solutions are chosen in cases where simple ones could have been applied. An example would be using a large inflexible machine rather than several small flexible machines. It can also appear when methods such as 'poka-yoke' are not used, leading to production of low quality goods.	Examples of inappropriate processing are repeated collection of data, unnecessary reports or transactions, internal messages, budgeting and monthly financial follow ups.
Unnecessary inventory	Having huge inventories tend to hide problems in the process, thus making it hard to identify and correct them. Also, this tends to increase the lead time and the required inventory space, leading to increased storage costs.	Examples of unnecessary inventory are boxes (physical or digital) overflowing with orders or documents that should be processed, or the processing of errands in batches.
Unnecessary movements	Occurs when the operators have to perform physical activities that could be avoided. This tends to reduce the productivity.	The movement of people around the office should be limited.

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Waste	**Workshop (Hines et al., 1997)**	**Office (Keyte et al., 2008)**
Defects	Defect products comprise direct costs for the organization and should be seen as opportunities for improvements.	Defects could be faults in design, construction, registration, invoicing etc.
Unexploited creativity		Is related to the skills of the employees and not their time, e.g. restricted integrity to perform certain tasks, the management's supervision, and inappropriate working equipment.

Many of the non-value creating activities (pre-requisite activities) cannot be removed unless the current business model is substituted or redesigned. When a company has decided to pursue a lean strategy, they thus have to make sure that their business model supports it. (Keyte et al., 2008, Melvin et al., 2008)

3.1.2 Implementation of lean

To aid the removal of wastes and the re-design of business processes several tools and concepts have been developed. It is important to understand that 'lean' is a *philosophy* and not a tool among others, which means that a successful implementation of it demands careful considerations. An important part of lean is to apply the correct tools in a correct way. On a top-level the introduction and implementation should go through five steps, which are presented in Figure 3-1 (Näslund, 2008).

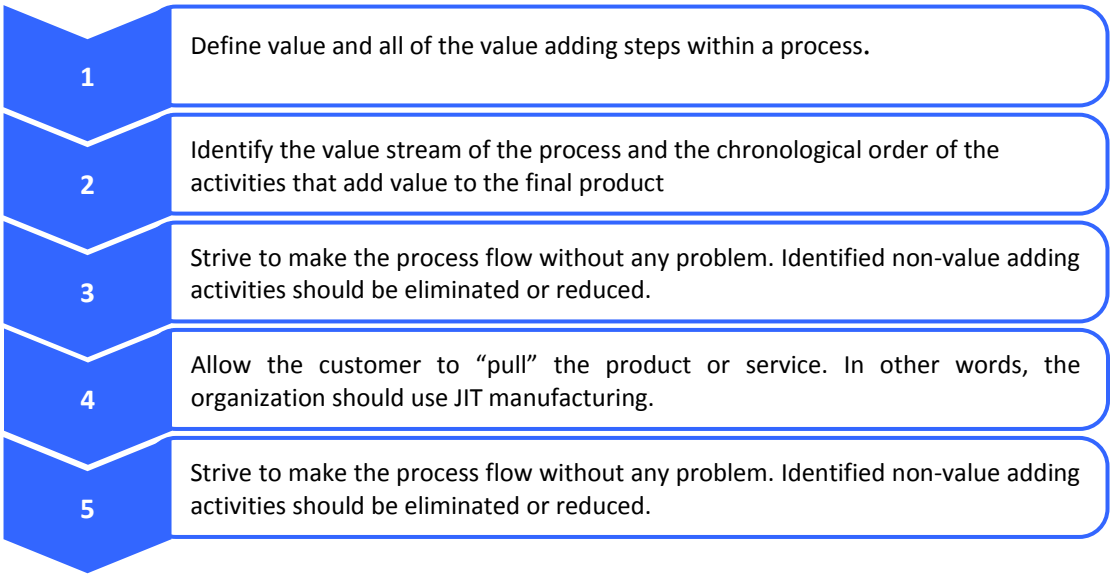


Figure 3-1 Value stream mapping implementation steps

In the first three phases the *Value stream mapping (VSM)* tool is essential. VSM comes down to objectively observe the flows of information and materials in the organization and then summarize them and present their key features visually in a map (Melvin et al., 2008,

Serrano et al., 2008). The map represents a great tool for communicating the *current state* and envisioning the *future state*, and its greatest strength is that it presents the process from end to end in a way that is comprehensible for everyone working in the process (Melvin et al. 2008, Serrano et. al, 2008, Prabhu et al. 2008). Most common is that waste appears in the *interfaces* between departments, and without the holistic description these are hard to discover (Näslund, 2008).

From the VSM of the current state wastes should be identified (Näslund, 2008). First it should be determined whether or not each of the described activities creates *value* for the final customer. A simple way to determine this is to ask the customer if they would be dissatisfied if the activity was not performed. Another factor to determine is whether the activity is *capable* or not. This involves an evaluation of if the activity achieves good results every time it is performed. The third factor that should be considered is the *availability* – can the actions always be performed when requested by the workers? In some organizations, *flexibility*, the possibility to switch between two different types of products, is important. Finally the *adequacy*, how well the activity can respond to customer's need when needed, should be determined. A low adequacy signals a risk that the activity could turn into a bottleneck. (Womack, 2006)

When the current state map has been established and the wastes identified, a future state map should be designed. Examples of improvements introduced in the future state map could be changes that eliminates rework, or a new design for a continuous flow (which should decrease lead times and cost). A major improvement could, if the company produces different kind of products, be to establish distinctions between these, and create separate value streams. To ensure that the suggested changes are introduced in a structured way, an *action plan* should be developed and then followed. (Womack, 2006)

The introduction of the changes could be a re-design of production layouts, changed routines and roles etc. Achieving this is an important first step, but a fundamental concept within the lean philosophy is to work with continuous improvements (Faulk, 2006). For this purpose there have developed a number of tools among which 'Kanban', 'Kaizen', 'Poka-yoke', '5 S' and '5 why' are some of the most common. These are presented in short in Table 3-2 below.

Table 3-2 Lean tools

Tool	Description
Kanban	Kanban is a tool used to achieve Just-In-Time deliveries in production. This is done by letting each function in production pull the right amount of material from the previous function at the right time. This could be either withdrawal (of already produced products) or production order based. Kanban could further be used in purchasing. (Richards, 2009)
Kaizen	Kaizen is a Japanese management philosophy focusing on continuous incremental improvements, which has the elimination of waste as one of its main purposes. A common misperception is that the improvements have to be small, but good offensive quality work has to include both small and large improvement steps (Bergman et al., 2007). Waste could for example be avoided already in the design phase, by making the product more flexible in terms of use. Another principle is that value is determined by the customer. A well built product in line with Kaizen is thus one where customer gets what they want, including a minimum number of customized parts. (Faulk, 2006)
Poka-yoke	Poka-yoke is Japanese meaning mistake-proofing. A poka-yoke device prevents mistakes from being made or makes them obvious at a glance. The main idea is that errors made by the workers are the causes of defects. By detecting and eliminating the errors and their causes, defects can be prevented. (Grout et al., 2009)
5S	The 5 S-tool is used to create order, which is seen as a prerequisite to be able to attack the wastes. Each of the S's represents a Japanese word which is used as guide. *Seiri* means tidiness which indicates that the tools that are needed and only these should be present in the workplace. *Seiton* means orderliness which indicates that everything should be sorted and labelled. *Seiketsu* means standardization and indicates that the cleaning should be standardized. *Seiso* means cleanliness and indicates that the workplace should be kept clean. *Shitsuke* means discipline and indicates that the rules connected to the 5S always should be followed. (Bergman et al., 2007)
5 why	A good start in the lean orientation is to identify wastes and to apply the '5 Why-technique' on them. This technique aims to identify the root causes of the problem, by asking the why five times. To be effective in the work of eliminating wastes it is important to start with the big picture and start focusing on the areas that are critical. (Keyte et al., 2008)

3.2 *Processes*

In this subchapter theory on process thinking, mapping, design and management will be presented.

Key insights

- Process orientation is not a management tool but a fundamental way to look at business organization
- In order to fully understand the process it needs to be mapped
- The process map should be the natural source of information about how work is conducted
- A measurement system that supports the process is key
- The next step is to work with inter-organizational processes

3.2.1 Introduction to process thinking

To be able to work efficiently and effectively with process orientation and management it is important to have a clear understanding of what defines a process and what role it plays in an organization. A good introduction is to recapture the origin of process thinking and the problems that it was intended to solve.

The traditional way of describing an organisation is with an *organization chart* (see Figure 3-2). The chart clearly shows the hierarchical structure of the company, but not where the customer fit in or the flow of products or services that the company provide. The organization chart hence leaves out what kind of business is conducted, how it is conducted, and for whom it is conducted. The organization chart still has its functions though, e.g. how the people are grouped together for operating efficiency and the reporting relationships are arranged (Tisher, 1993). (Rummler et. al, 1991)

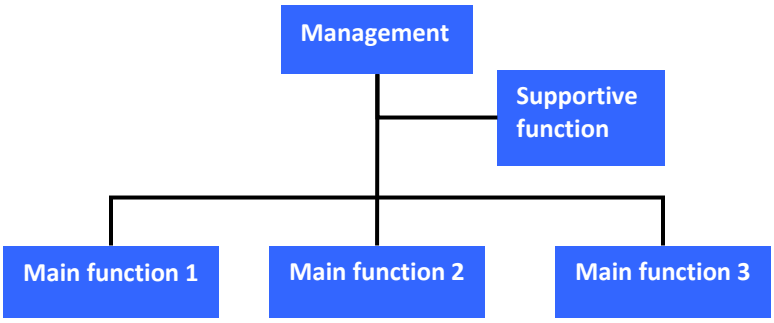


Figure 3-2 Conceptual design of a traditional organization chart

The problems related to the organization chart arises when executives use it as a management tool and manage the different departments as if they were closed "*silos*" (Tisher, 1993, Rummler et al., 1991). All cross-functional concerns are not solved on middle or lower levels but pushed to the top of each function. This tends to have a

negative effect on employees willingness to work with improvements (Tisher, 1993). The biggest problem with this way of managing the company is that different departments (silos) tend to set their own goals, and try to excel according to these (Galagan, 1992). At the same time they tend to disregard the effects this behaviour might have on the work of other departments (Neely et al., 1995). The sales department might for example agree to very specific customer wishes in order to increase sales, which leads to problems and increased costs for design, engineering and production. In the same way the R&D department might design sophisticated products that customers are not willing to pay for, which causes problems for sales and marketing. (Rummler et al., 1991)

The *horizontal view* for a start includes three missing factors that the organization chart does not present, namely the customer, the product and the workflow. The horizontal view displays the processes that constitutes the way the work gets done, and also clarifies the internal supplier-customer relationships that exists in the interfaces between functions/departments. The greatest opportunities with process management lie in the improvements of the handovers in the interfaces between functions. An important insight related to a process perspective and the horizontal viewpoint is that it links strategy and organizational structure to job performance, which makes it a natural key to organizational performance improvement (Baker et al., 2005). (Rummler et. al, 1991)

The definition of what a process is differs to some extent between authors, but most of them agree on what is called the *transformational model* (see Figure 3-3) (Baker et al., 2005). The definition of a process according to this model is an activity or group of activities that take input, adds value to it, and provides an output (Baker et al., 2005, Bentley, 1995, Berente et al., 2009). The input and output are usually constituted of both material and information but studies shows that even in manufacturing processes the latter is dominating (Kock et al., 1997)

The process converts the input to the output, and can be used on different levels of detail. It can be used to describe the entire process (e.g. production, order handling) or the work of the involved individuals (activities), and comprises both a supplier and a customer (Kock et al., 1997, Baker et al., 2005). In the case where the description comprises an entire process it clearly includes cross-functional interfaces, and most processes that deliver products or services to external customers are of this type. (Baker et al., 2005)

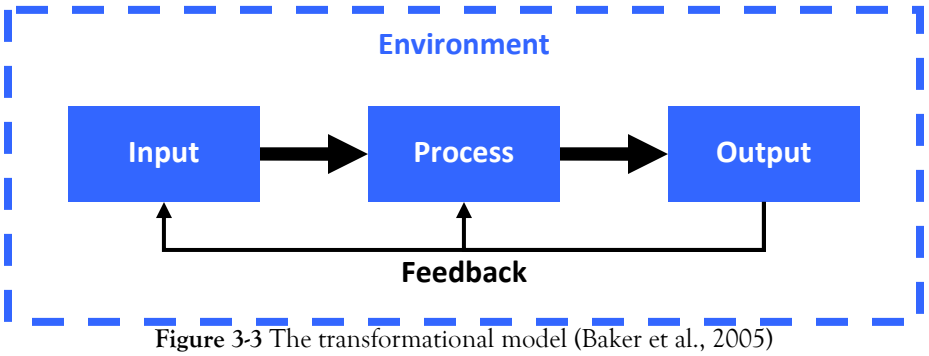


Figure 3-3 The transformational model (Baker et al., 2005)

The definition above is the well established, and appealing since it is both simple and comprehensible. The question is whether or not it captures all that is necessary to describe a process. If the social aspects are included, considering that not all aspects can be controlled with simple cause and effect relations an alternative definition can be formulated (Ljungberg et al., 2001):

"A process is a repetitively used network of in order linked activities that use information and resources to transform 'objects in' to 'objects out', from identification to satisfaction of the customer's needs".

This definition emphasises that focus should be on customer needs, since the satisfaction of these is the main purpose of a process (Bentley, 1995, Hammer, 2007i, McCormack et al., 2005). If the process is not connected to satisfying a customer need (internal or external) it has not got any right to exist (see previous discussion on waste) (Keyte et al., 2008). Customer needs can also be used to find the boundaries of a (sub) process. A process always starts with an identified customer need and always ends when this need is satisfied. Further this definition states that a process does not include resources, but instead uses resources provided from the organizations different competence centres. It is thus important that the resources available coincide with the process needs. Another important issue to consider is the information flow, to and from processes (Ljungberg et al., 2001). The transformational model presented above could with this definition be developed further, see Figure 3-4.

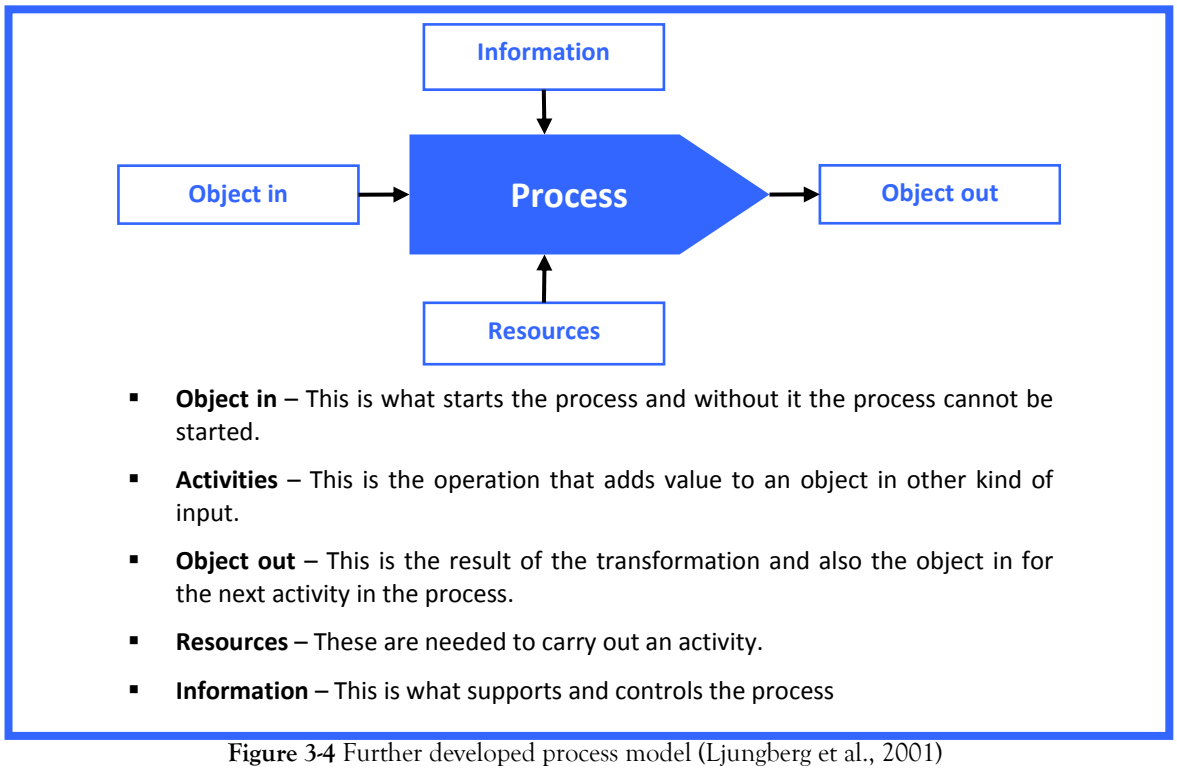


Figure 3-4 Further developed process model (Ljungberg et al., 2001)

3.2.2 Process mapping and design

When identifying processes it is often appropriate to start with the products created in the organization. This could range from internal documents to external deliveries to customers. A product should be the final result of a process and thereby satisfying a specified need (Ljungberg et al., 2001).

The best way of describing a process is by visualising it and thus process mapping has become the main tool for describing processes (in the same way VSM is an essential tool in the lean toolbox) (Galagan, 1992, Ljungberg et al., 2001, Recker et al., 2009). Problems that exist in the interfaces between different departments do not usually show until you draw the map. The process map also serves the purpose of describing the needs of the customer, and how each sub process and activity is related to them, to the people involved in the process. Some of the functions of the process map are summarized in the table below. (Ljungberg et al., 2001)

Table 3-3 Functions of the process map

Functions of the process map (Ljungberg, 2001)
▪ Creates a common view of how operations are conducted
▪ Creates an understanding for how customer value is created
▪ Clarifies the impact the process perspective can have on the organization
▪ Creates process oriented measurement systems
▪ Is the base of process analysis

The process maps exist on different levels of abstraction. The *main process map* is the highest level and constitutes an overview of the organizations most important processes (and possibly the most important management and support processes). The main process map should also present the most important connections, internal as well as external (Galagan, 1992) and communicate what is important in the operation of the business. (Ljungberg et al., 2001)

The information content in the map should be balanced so that it is informative enough but not cluttered up. The process map should also be complemented by a process specification for each process. This is a document that includes information about the process, its purpose; object in and out, measuring points etc. Depending on the extensiveness of the process, it could be necessary to break down every process map into several levels. (Ljungberg et al., 2001)

Since processes are used to describe the work being carried out in the organization, the design of these are of vital importance for the organizational performance, and though organizational design, employee motivation and competence are important they cannot compensate for the lack of a good process design (Hammer, 2007i, Baker et al., 2005). The term 'process design' could be defined as "...the specification of which people must

perform what tasks, in what order, in what location, under what circumstances, with what information, and to what degree of precision". Process improvement techniques such as Six Sigma[1] and TQM[2] often can make sure that employees perform their tasks correctly, but process re-design is often the only way to improve performance significantly. A potential problem arises when companies try to establish a 'high performance process' framework on an existing functional organization. The already established structures such as job definitions, performance measurement systems and management hierarchy do not always support these new processes. A holistic viewpoint is important, meaning that the old structure has to be altered or replaced in connection with the establishing of the processes (Galagan, 1992). This means that you will have to be willing to put in resources and pay the costs related to the redesign of measurement systems and the training of employees and management. (Hammer, 2007i)

3.2.3 Process management and evaluation

Just as Lean, process orientation should not be seen as another management tool but as a philosophy. In order to be successful, performance improvement initiatives such as the balanced scorecard, supply chain integration, and Six Sigma must all be implemented under a "process-management umbrella" (Hammer, 2002). An important insight is that it often is of little use to implement a process perspective in one department or function of a company (Baker et. al, 2005). There are on the other hand examples where process perspectives have been successfully implemented in business units (Hammer 2007i).

To be successful in managing a process organization it is important to first have identified the company's processes and to create an awareness of them (Galagan, 1992, Hammer, 2002). Next management must establish individual goals for each critical process that in turn can be broken down into functional goals (Hammer, 2002, Baker et al., 2005). These goals must be supported by feedback collecting on process output to ensure that performance is on track, as well as with the appropriate resources (Hammer, 2002, Baker et al., 2005). One of the most challenging tasks in process management is the handling of the "white space" between process steps, or hand-offs between functions (Baker et al., 2005). The management system must thus be gradually aligned with the processes (Hammer, 2002).

A framework for evaluating the level of process orientation is the PEMM (Process Enterprise Maturity Model) and by applying it to their business managers and directors can identify areas in which they could improve. The model includes two sets of characteristics that have major impact on process performance which are presented in Table 3-4 below. The 'process enabler's are connected to the actual process performance over time, while 'enterprise capabilities' are more related to how well the corporate structure supports the process. The framework shows that improving your processes and becoming process oriented is not easy, and that you do not have to go from nothing to perfection in one

[1] *Six Sigma* – a business management strategy focusing on finding and eliminating causes of error in business processes
[2] *TQM* – a business management system aimed to embed awareness of quality in business processes

giant leap. The PEMM is easy to use even for people that have no previous training in processes and can be used as subtle way of engaging them. (Hammer, 2007i)

Table 3-4 PEMM components

Process enablers	Enterprise capabilities
Design – The comprehensiveness of the process. **Performers** – The skill and knowledge of the people executing the process. **Owner** – The appointment of a top level process owner that overseas the process. **Infrastructure** – The match between the organizations information and management systems and the process's needs. **Metrics** – The quality of the metrics which are used to measure process performance.	**Leadership** – Senior management supports the focus on processes. **Culture** – The employees greatly value customers, teamwork, and personal accountability. **Expertise** – The organization employs people who know how to redesign processes, and are able to handle complex problems. **Governance** – Mechanisms for managing complex projects and change initiatives.

The PEMM model framework can be found as Appendix A and B.

3.2.4 The next step in process orientation

Organizations that work actively with process improvements will eventually reach a stage where they are lean and efficient, with well documented processes and coordinated measuring systems. One might think that this is the end of the process journey, but with a broadened perspective this is only the beginning.

Process integration should be a main focus when working with process improvements (Berente et al., 2009) and the next step is to move beyond the barriers of the organization and look at the *interfaces* with other organizations, such as customers and suppliers (Hammer, 2002). A key insight is that a lot of the activities performed at each side of the interface to a large extent are the same. This means that a lot of time is wasted. Also, because of the "barriers", mistakes, misunderstandings and inconsistencies continuously occur which leads to even more waste of resources and time. The problem is often that since this occurs outside the company walls, it usually does not show in the measuring and accounting system, though still resulting in *increased costs*. (Hammer, 2001)

In the integration of processes the information flow is of fundamental importance (Berente et al., 2009) and the Internet and the companies *ERP-systems* hence are important tools (Hammer, 2001). Creating an inter-organizational system (IOS) is not an easy task and further demands both a strong external (neutral) as well as internal leadership (Volkoff et al., 1999). Good information systems cannot support integration on their own though. It is instead important to change the perception that processes stop at the company wall, and instead establish a view of the process running through the entire *supply chain*. This could be facilitated by establishing personal relations on several hierarchical levels (Volkoff et al.,

1999). The integration can e.g. involve transferring an activity performed in a company to another one, because of the possibilities to perform it more efficient.

The technological impact usually involves the sharing of information between multiple companies. The information must be correct and available when needed and it must be understandable and have the right level of detail (Berente et al., 2009). The more companies that are involved in the supply chain, the greater is the possible impact of an integrated information system (Hammer, 2001).

To integrate different department when working with internal processes is not an easy task. To make separate companies integrate in the supply chain is even harder. Four stages in this work have been identified and they are presented in Figure 3-5 below.

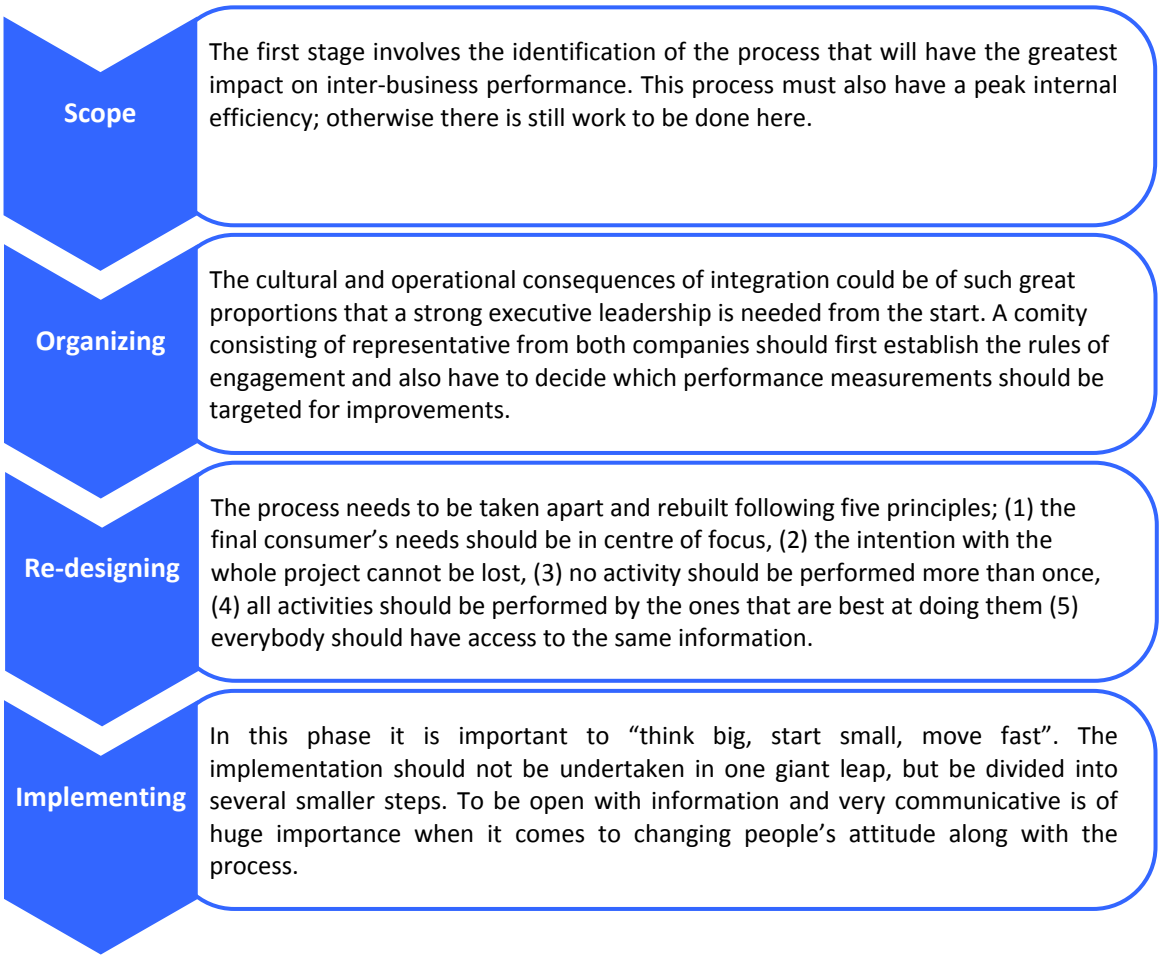


Figure 3-5 Four steps in inter-organizational process integration

3.3 *Performance Measurements*

Lean thinking and process orientation are two important philosophies in the modern management of an organization, but in order to be successful with these an adequate measurement system must be implemented. In this chapter this subject will be investigated.

Key insights

- A performance measurement system is a group of metrics used to calculate the efficiency and effectiveness of an action
- There are a number of characteristics that need to be considered when developing a measurement system, e.g.:
  - Measures should be easy to understand and communicate
  - Measures should focus on improvements
  - Measures must be well-defined and accurate
- The measurement system must be developed systematically
- Process orientation is a prerequisite for good measurements
- There are seven sins when it comes to measurement systems which should be avoided; vanity, provincialism, narcissism, laziness, pettiness, inanity and frivolity

3.3.1 Defining a good measurement system

A definition of what a measurement system is could be formulated as:

A performance measurement is the process to quantify the efficiency and effectiveness of an action. These efficiency and effectiveness are quantified using metrics that can be defined as performance measures. A group of these metrics can be identified as a performance measurement system. (Bourne et al., 2003)

Performance measurements are employed in very different parts of a business and good managers use performance measurements to follow and track the performance of the system they are responsible of. The measurements can be both financial and non-financial, and can be used for measuring how the company is doing internally as well as in an external environment (Neely et al., 1995). The purpose of the performance measuring is to help companies determine what objectives have been achieved and to help in the efforts of forecasting the future (Davidson, 2006, Lingle, 1996). Often performance measurements are also used to identify how well each employee is performing his/her tasks and hence the measures are important for everyone within the organization. Good measurements make people aware of how the company is doing and influence them to take actions according to of the result (Neely et al 1995). (Bourne et al., 2003)

There are several opinions about what characterizes a good measuring system, and depending on the context some of these are more relevant than others.

In general the performance measurement system should be derived from strategy (Joiner et al., 2009) and be in line with the business overall operating goals and objectives (Lingle et

al., 1996). The performance measurement system should ideally present how well the customer's needs are met, and the most important measurements are thus the ones visible to the customer. To ensure that focus is not lost the measurement system should provide the relevant information with a minimal number of measures (Lingle et al., 1996, Sebago, 2006). These should all have an explicit purpose and be part of a closed management-loop, making the results usable in improvements work. (Dixon et al., 1990, Bourne et al., 1997).

When it comes to the measuring it is important that the measurements are exact to ensure that the results are valid (measuring what is intended) and reliable (giving consistent results when repeated) (Bourne, et al., 1997, Pyzdek, 2001). This could only be achieved when the measurements are clearly defined, and based on data which is automatically collected. The results should be presented as ratios rather than absolute numbers to make them simpler to understand for the members of the company (Bourne et al., 1997). In addition, measurements should be accompanied by an indication of how well they are meeting the current target. These targets should be tough but reachable; and whenever these are accomplished a new more challenging goal should be defined (Fortuin, 1988, Bourne et al., 1997). It is important that targets are used as goals to strive for in order to increase business performance rather than as incitements for bonuses (Bourne et al, 2008).

One important set of characteristics is connected to feedback of the results. A measurement system should start with organizational goals, which are broken down into individual goals for the employees (Bourne et al., 2008). Good measures should provide relevant feedback and information to the people whose performance is being measured, allowing them to observe the effects of their actions and decisions have on the business performance. This will support learning and improvement within the organization, but at the same time this demands that the people affected have the means and opportunity to influence the results. Other important characteristics when it comes to communicating the results are that the measures are visible to everyone and simple to understand. (Lea et al., 1989, Dixon et al., 1990).

In Table 3-5 Bourne et al. (1997) have summarized some of the above mentioned recommendations (and more).

Table 3-5 Recommendations with regard to the design of performance measures

The table have been slightly modified by the authors (the source references for each recommendation have been removed).

Recommendations (Bourne, 1997)
1. Performance measures should be derived from strategy
2. Performance measures should be simple to understand
3. Performance measures should provide timely and accurate feedback
4. Performance measures should be based on quantities that can be influenced, or controlled, by the user alone or in co-operation with others
5. Performance measures should reflect the "business process" - i.e. both the supplier and customer should be involved in the definition of the measure
6. Performance measures should relate to specific goals (targets)
7. Performance measures should be relevant
8. Performance measures should be part of a closed management loop
9. Performance measures should be clearly defined
10. Performance measures should have visual impact
11. Performance measures should focus on improvement
12. Performance measures should be consistent (in that they maintain their significance as time goes by)
13. Performance measures should provide fast feedback
14. Performance measures should have an explicit purpose
15. Performance measures should be based on an explicitly defined formula and source of data
16. Performance measures should employ ratios rather than absolute numbers
17. Performance measures should use data which are automatically collected as part of a process whenever possible
18. Performance measures should be reported in a simple consistent format
19. Performance measures should be based on trends rather than snapshots
20. Performance measures should provide information
21. Performance measures should be precise – be exact about what is being measured
22. Performance measures should be objective – not based on opinion

3.3.2 Designing a measurement system

When designing a measurement system, the design process can be categorized based on two different kinds of features, the procedures and the approach, which are presented in Table 3-6 and Table 3-7 below:

Table 3-6 Performance measurements design procedures

Procedures (Bourne, 2003)	
The 'Needs led' procedure	Measures are designed to supervise the business's activities towards fulfilling the needs of the customer, the business and the stakeholders. This is a top down procedure since management should have established from the start the needs of all above mentioned groups.
The 'Audit led' procedure	This could be considered a bottom up approach because it starts with an inspection of the existing performance measurement system to determine how it is working and in which ways it can be improved
The 'Model led' procedure	This procedure involves using a theoretical model of the organization as a basis/rationale for designing the measurement system.

Table 3-7 Performance measurements design approaches

Approaches (Bourne, 2003)	
The 'Consultant led' approach	**The 'Facilitator led' approach**
The job is done by an individual or a group of people excluding the management team. The consultant collects the data and analyzes it. Later, they present the results of the analysis as well as the possible improvement recommendations to the management. In the end the management makes the decisions.	Here most of the work is done by the management team, who are deeply involved in the analysis phase of the work. The facilitator's role is to guide them in this process, structuring the debates and challenging the decisions made.

If the two feature sets are put as dimensions, the matrix in Table 3-8 below can be created. For five of the six combinations of procedures and approaches a model for designing has been developed.

Table 3-8 Performance measurements design models

	Consultant Led (C)	Facilitator Led (F)
Needs Led (N)	1) Putting the balance scorecard to work	2) The performance model 3) Getting the measure of your business
Audit Led (A)	4) The performance measurement questionnaire	
Model Led (M)	5) ECOGRAI	6) The Fraunhofer Approach

1) Putting the balance scorecard to work (N, C)
The balanced scorecard is constructed in a way so that key components of strategy are tracked, involving different areas such as continuous improvements and teamwork (Kaplan et al, 1992). What differs it from many local measurements that exist in the organization is that it is top-down instead of bottom-up (Kaplan et al., 1993). In this design model, consultants determine the customer's needs through interviews either with the managers or directly with the customers. Later the results are introduced into the balanced scorecard development process and thereby better measures are achieved. (Bourne et al., 2003)

2) The performance model (N, F)
This design model takes into consideration the fact that managers know how their business works. Based on this assumption, a facilitator asks them which the objectives to be achieved are and how they are achieved. By asking these questions to several managers the facilitator is able to join this knowledge and create a performance model based on the "business needs" (Kaplan et al., 1996). It also has the effect that senior management has to agree on and concretize their vision (Kaplan et al., 1996). (Bourne et al., 2003)

3) Getting the measure of your business (N, F)
In this design model a facilitator guides the management team through a series of exercises to analyze the business. However, all the knowledge about the business comes from the managers.

It is divided in five stages which contain the procedures to determine the business objectives and the design of the performance measures for a business unit. The first stage involves *grouping of products* – identifying group of products with similar customer needs. The second stage is *agreeing business objective* – development of overall business objectives. The third stage is *agreeing performance measures* – assigning individual measures to the business objectives. The fourth stage is *signing off the top-level performance measures* – the measures from the third stage should be tested before they are implemented. The fifth stage is *embedding the top level performance measures* – providing advice on the implementation of the measures and use of performance reviews. (Bourne et al., 2003)

4) The performance measurement questionnaire (A, C)
This design model is used to evaluate the performance measures that are already in use at the company (Vollmann, 1991). The questionnaire is based on the idea that the measure should support and reward performance improvements. The model ask the respondents to score significance of specific improvement, to score how the performance measures monitor improvements and to score how important it is for the long term to achieve good results in a specific measure (Vollmann, 1991). The results should then be analyzed to identify *alignment* (importance of the improvement area) (Schmenner et al., 1993), *congruence* (difference between what the respondents considered as important and if the measurements support it) (Schmenner et al., 1993), *consensus* (data is categorize by different management levels and functions to determine if the degree of agreement) and *confusion*

(analyze the disparity in the response within groups) in the answer of the respondents. (Bourne et al., 2003, Dixon et al. 1990)

5) ECOGRAI (M, C)

This design model is a structural methodology for the development of the performance measurement, and can if combined with ABC cost calculations be used in business reengineering projects (Tatsiopoulos et al, 2000). The process begins with an analysis of the whole system and the information flow using a technique called GRAI grids (Tatsiopoulos et al, 2000). Using this technique the activities are divided in management of the activity, planning of the activity and management of the resources used. Through this analysis the main decision centres (MDC) can be identified. These constitute the activities that have a main influence in the global objective of the system. Later the main system objectives are linked with the MDCs to verify its coherence. Afterwards, the decision variables are determined; these are factors that the responsible of the process can influence in pursuit of the business objectives. Finally, the performance indicators are designed from the objective and decisions variables. (Bourne et al, 2003)

6) The Fraunhofer Approach (M, F)

This is based on the Integrated Enterprise Modelling Method (IEMM) and a process mapping tool. The process map helps to identify the critical success factors, which then are used for the design of the performance indicators. The performance indicators are within the categories from the balanced scorecard model (Kaplan et al., 1992): financial, market structure, business process and innovation and learning. It is a six-stage process: develop a value chain process model, identify the critical success factors, define the performance indicators, gather and verify the data, evaluate the performance indicators and implement a continuous process. (Bourne et al, 2003)

3.3.3 A framework for performance measures

Bourne et al. have, with basis in the recommendations summarized in Table 3-5 developed a framework for performance measures. The framework makes sure that the measures are clearly defined and that they are based on an explicit formula or source of data. The framework is summarized in Table 3-9 below.

Table 3-9 Performance Measure Record Sheet

Performance Measure Record Sheet (Bourne, 1997)
▪ Title ▪ Purpose ▪ Relates to ▪ Target ▪ Formula ▪ Frequency ▪ Who measures? ▪ Source of data ▪ Who acts on the data? ▪ What do they do? ▪ Notes and comments

The title of the measure should be self explanatory in terms of what it is and why it is important (Lea et al., 1981). A prerequisite for introducing a measure is that it has a purpose and that it can be related to a business objective (Lingle et al., 1996). The purpose is, in the general case, to provide decision makers with relevant information (Elg, 2007). The targets that are set must be related to stakeholders' expectations, especially the customer (Eccles, 1991, Ghalayini et al. 1996). To specify the formula (how the performance is measured) is one of the most challenging tasks, since it will influence how people behave. If they are not properly thought through they can lead to for the company unfavourable behaviour of the employees (Eccles, 1991). The frequency of the measuring relates to the importance of the measure as well as the amount of data available, and should be adjusted so that each new measuring shows distinctive progress (Fortuin, 1988). The person responsible for the measuring as well as the source of data should be identified (Blekinsop et al., 1992). The measuring as well as the source of data must be consistent over time (Fortuin, 1988). The person who should take action depending on the measured results must be identified. The last point 'What do they do?' is probably the most important. If the management loop is not closed and actions in accordance with the measures are not taken, then the measuring is pointless. Typically, the actions are of the following type: the results are publicized at the shop floor, a continuous improvement workgroup is set up and the commonly occurring problems are identified and reviewed by the team to try to come with improvements. Improvement of a measure could be an increase, but could also be a decrease in variation (Neely et al., 1995). (Bourne et al., 1997)

3.3.4 Common problems with performance measurements

To conclude this chapter on performance measurements, this subchapter will focus on the problems that often are mentioned in relation to them.

Very few managers are satisfied with their operational performance measurements, a pattern that can be seen across countries and industries. Too many of the measurements do not seem to make much sense but despite this they have not been given much attention. Michael Hammer has identified seven "sins" when it comes to measurements. The first sin is *vanity* – the measures are often constructed in a way that makes the company look good. Delivery accuracy is for example often measured against last promised date instead of the customers required date, making it relatively easy to a get a good result for this measure, while not ensuring customer satisfaction. The second sin is *provincialism* – the measures are often limited to different functional departments, which cause problems since most departments have different incitements (Neely et al., 1995). Sales departments are for example often evaluated on volumes sold, and might therefore sell solutions that are difficult for other departments to handle. The third sin is *narcissism* – the measures are often selected by the producer/distributer of a product based on what they believe that the customers want, rather than by asking for the customer's opinion (Ghalayini, 1996, Neely et al., 1995). The fourth sin is *laziness* – frequently companies do not bother to check that the measurements are measuring what they are supposed to. They often measure what they have always measured, or what is easy to measure (Hammer, 2001, Bourne et al., 2003, Davidson, 2006). The fifth sin is *pettiness* – it is important to not be locked into old

superstitions and habits when choosing measures (Wisner et al., 1991). An action that deteriorates one measure might improve the result for the company as a whole. The sixth sin is *inanity* – it is important to think over what kind of behaviour is encouraged by different measures. This behaviour can be counterproductive, especially if there is a reward involved (Neely et al., 1995). The seventh sin is *frivolity* – to understand why the measuring is done, and to take it seriously is of great importance. It is of no good to argue about a measure or to try to put the blame on someone else (Neely et al., 1995). (Hammer, 2007ii)

To redeem the above mentioned sins there are four steps presented in Figure 3-6 (Hammer, 2007ii):

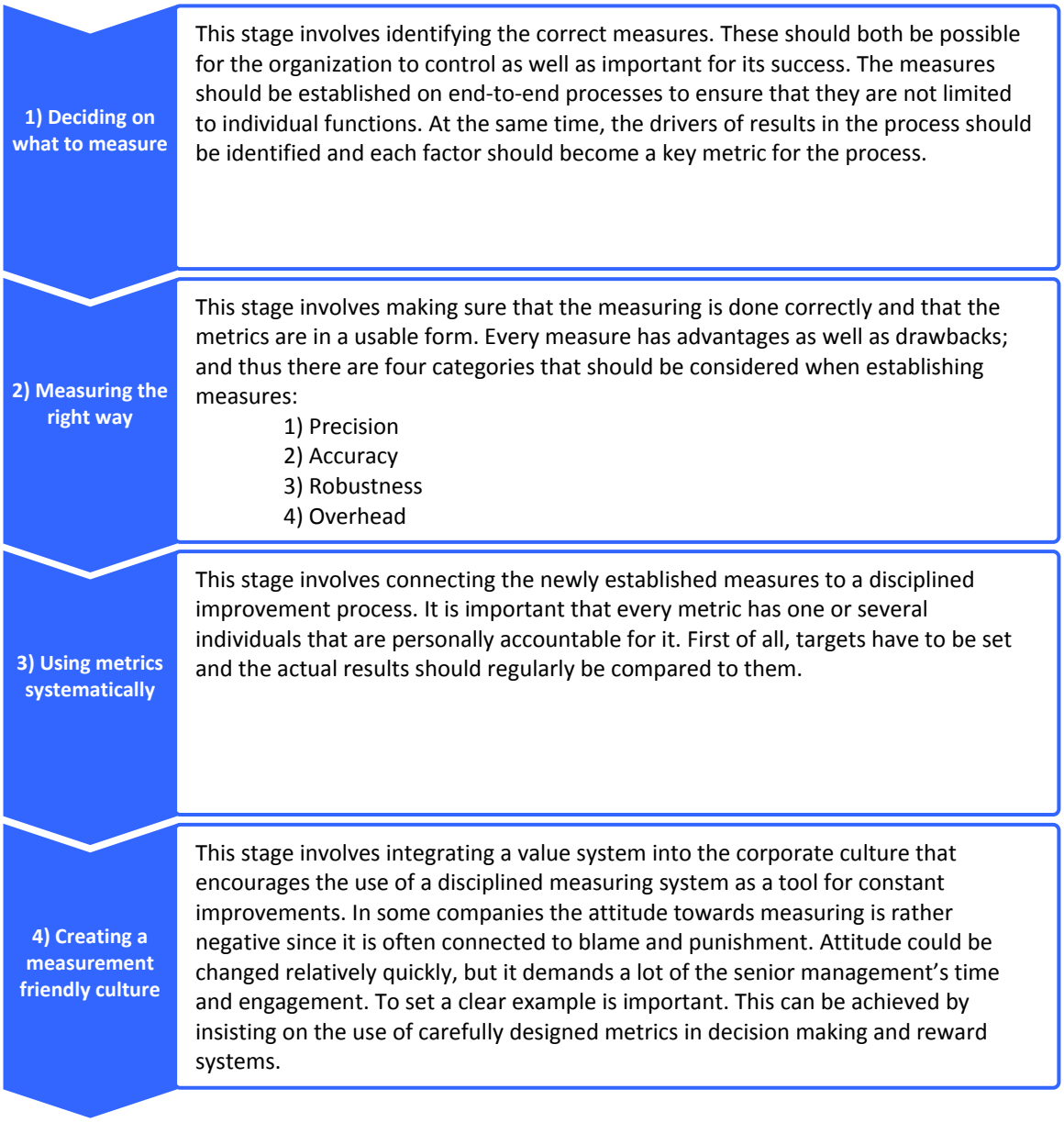


Figure 3-6 Four steps in redeeming the measurement sins

4 EMPIRICAL DATA - DESCRIPTIONS

In this chapter descriptions of the important components of the case are given. The chapter is divided into four main areas focusing on respectively Tetra Pak and BU DBF, the OFCE-process, the New Milestones measurement system, and World Class Manufacturing initiatives.

4.1 Corporate description

To give the reader a better idea of the context in which the process exist, this subchapter will describe Tetra Pak as a company, both through the history and in present time. It also aims to describe the role of BU DBF.

4.1.1 A brief historical overview of Tetra Pak

Tetra Pak was founded in Lund in 1951 by Ruben Rausing and Erik Wallenberg as a subsidiary to Åkerlund & Rausing. Rausing had got the idea of tetrahedron-shaped milk carton (see Figure 4-1) already in 1943 and in 1952 the first packaging machine was delivered to a local dairy. Throughout the rest of the decade the company continued to develop new product solutions at the same time as production capacity grew. By 1959 the Lund factory had the capacity to produce 1 billion milk cartons a year, which were licensed to eight countries.

Figure 4-1 The tetrahedron shaped milk carton (tetrapak.com, 2009-02-24)

The 60's gave rise to new products such as Tetra Rex and Tetra Brik. At the same time Tetra Pak expanded into new markets both in the West such as Mexico and the US, in the east such as the USSR and the Middle East. By the beginning of the 70's Tetra Pak had expanded as far as to Japan, where a factory was opened. The production capacity this year (1971) reached 10 million packages. By 1977 the production capacity had been doubled and new markets among others included China.

Throughout the end of the 70's and the beginning of the 80's new products were launched at the same time as the old ones became even more popular. In 1985 Tetra Pak acquired Alfa-Laval Logistics AB, a developer of distribution equipment for the dairy and food industries. By 1989 the production capacity reached 50 billion packages.

In 1991 another important acquisition was made, when Alfa-Laval, one of the world leading suppliers of equipment and plants to agricultural, food and processing industries, is bought. The Tetra Pak Alfa-Laval Group is thereby formed.

During this latest decade China has grown to be one biggest market for packages. Focus within the company has shifted towards producing cost effective solutions and reduce the impact on environment. In 2007 Tetra Pak delivered more than 137 billion packages. Tetra Pak is today a global company with locations all over the world (see Figure 4-2).

Figure 4-2 Tetra Pak locations worldwide (tetrapak.com, 2009-02-24)

4.1.2 Tetra Pak's organization and the role of BU DBF

Tetra Pak as it is organized today differs a lot from the company that was founded some fifty years ago. The company has grown both organically and by acquisition and today it involves a number of different yet still related operations. Tetra Pak exists as one part within the Tetra Laval Group together with Sidel (Glass and PET-bottle solutions) and Delaval (agricultural equipment). The Tetra Pak Group, shown below in Figure 4-3, consists of two main business areas; Packaging solutions and Processing solutions.

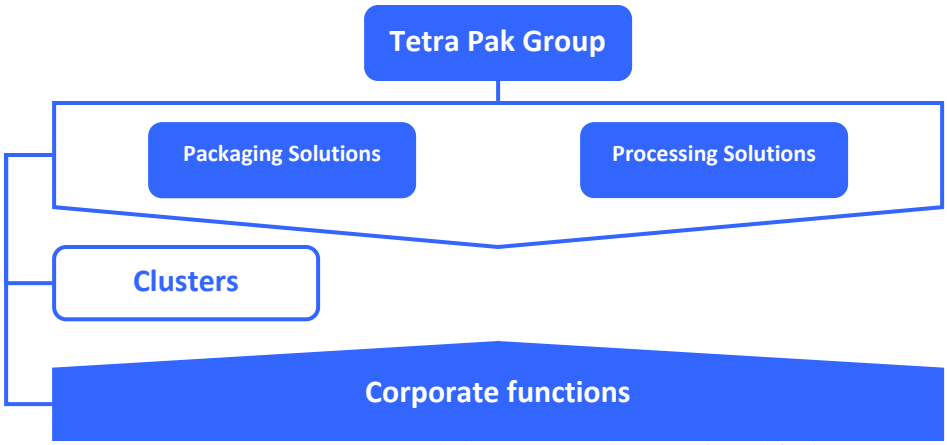


Figure 4-3 Organizational chart, Tetra Pak Group (simplified)

Processing solutions is handled by the company Tetra Pak Processing Systems (TPPS) which in its turn is divided into 'Market Management', 'Processing Components' (who develops and produces homogenisers, separators etc.), 'Global Projects, Plant Automation, Plant Solutions' (who deals with large development and engineering projects) and three business units working with development and production of process equipment for different types of food/beverages (see Figure 4-4).

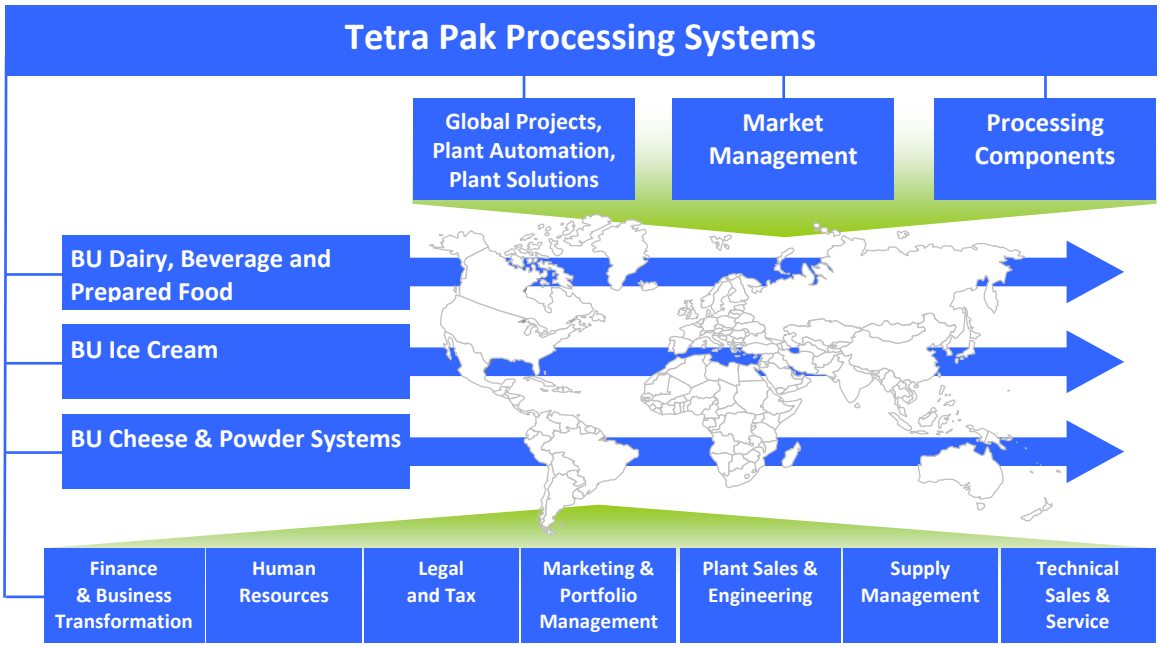


Figure 4-4 Organizational chart, Tetra Pak Processing Systems

Business Unit Dairy, Beverage & Prepared Food (BU DBF) develops and produces processing equipment and the range of different products includes pasteurizers, dosing system, high temperature treatment systems etc. A summary of the most common products can be seen in Appendix C. In 2007 Tetra Pak delivered 2 107 processing units world wide which raised the number of units in use to 28 643 worldwide.

4.2 OFCE-process description

This subchapter will describe the main parts/functions of the OFCE-process and will focus on what is essential to support the understanding when reading further. A list of all the abbreviations used in this chapter can be found in Appendix D.

4.2.1 Important concepts and external relations

In order to understand the nature of the problems suggested in relation to the work conducted in the OFCE-process there are some terms/concepts that need to be considered (see Table 4-1).

Table 4-1 Important terms/concepts, OFCE

Concept	Definition
Customer focus	The customer focus within Tetra Pak is important, and something that is emphasized all the way from top management. The first of April 2009 a summary of the 2008 results was presented on the intranet accompanied by a statement by CEO Dennis Jönsson – "During these economically difficult times it is more important than ever to provide our customers with value-driven solutions. With our current strategy, investments to meet market needs and drive to continuously improve quality and operational efficiency we are well positioned to support our customers to remain competitive".
Customization	An order could on a general level be of two types: *Price book orders* – are based on standard products, which include several options. For these orders there exist product specific order forms that should be filled in by the Market Companies. *Quotation orders* – include customer specific solutions or customizations that are not possible to specify within the frame of the Price book.
Lead time	The *lead time* in the OFCE-process is measured as the actual time spent working on an order. A long time strategic goal is to minimize it, leaving it significantly shorter than the delivery time.
Delivery time	The *delivery time* is the time elapsed from the receiving of an order till the product is shipped from the workshop. For Price book orders this time is specified in advance while it is case dependent for quotation orders. Typically an order has a delivery time of ten to twelve weeks.
Cost structure	One goal with monitoring the OFCE-process is to make sure that the costs are evenly spread through out the process and that capacity is adjusted to the current need. When delays occur, the costs related to overtime and the uses of external capacity are expected to be considerable in late stages of the process. Furthermore delays are more expensive later in the process considering that the accumulated costs are larger, thereby increasing the cost of capital.

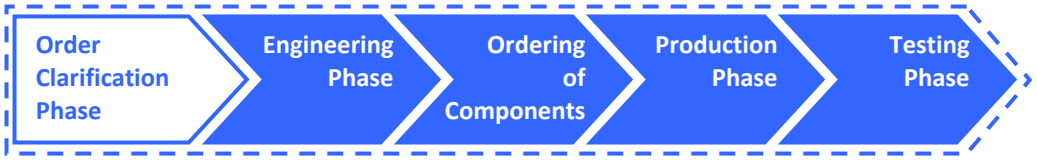
To be able to provide the customer with their requested solution BU DBF has to interact with external partners. Before looking at the OFCE-process these are briefly introduced in Table 4-2 below.

Table 4-2 External relations, OFCE

External relation	Function
Market companies (MC)	The Market Companies are the part of the Tetra Pak Group located closest to the customer and thus Tetra Pak's face outwards. The Market Company does not only sell the equipment engineered and produced by BU DBF but rather complete lines including everything from processing to packaging. The Market Companies are further divided into clusters (e.g. Northern Europe) and interact with a Sales Manager at BU DBF assigned to that cluster.
Tetra Pak Processing Components (TPPC)	TPPC is a company within the Tetra Pak Group that develops and manufactures certain equipment, such as homogenizers and high-pressure pumps, tube heat exchangers, centrifugal separators, system components and control panels. TPPC produces components that are either used in the same line as the BU DBF's products or as components in the latter. Examples of the first could be tube heat exchangers and homogenizers while examples of the second could be vessels and control panels. It has been decided on a company level that these components must be purchased from TPPC.
Suppliers	BU DBF has a large number of external suppliers, which provide everything from simple valves to expensive customized pumps. The decision on which suppliers should be used is made either on a company level or by the central purchase department. The latter are responsible for the negotiations on contracts etc. while the ordering to specific orders are done by purchaser at BU DBF.

The OFCE-process essentially starts with the receiving of an order and ends when the product is running on site and handed over to the final customer. Further inquiries by the customer are handled by 'Technical Sales and Services' (see Figure 4-4).

4.2.2 Order clarification phase



Order receiving

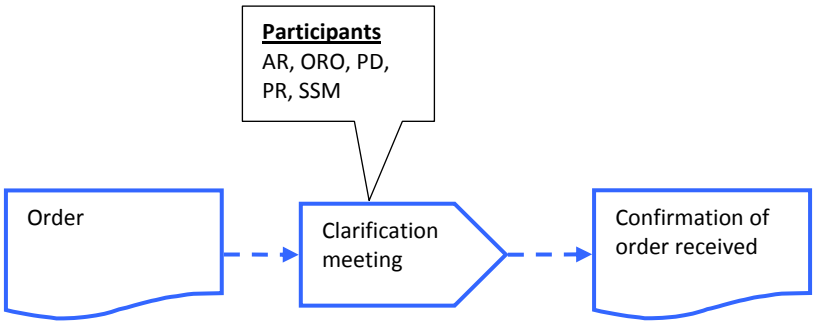
The order receiving phase starts with what is called 'Order reception'. The Order receiver (OR) decides whether the order should be classified as an M1, M2, or M3 type of order. *M1* orders include a predefined product with fixed specification. This could be a sub module or component(s) and it is intended to go straight into production. *M2* orders include a predefined product with configurable specification. No engineering is allowed and this type of order is also intended to go straight into production. *M3* orders include a customized, prototype or non-industrialized product.

The Order receiver is a newly introduced role and has yet to be assigned to a particular person in the different food categories. If handled as intended this part of the process should be completed within minutes.

Order clarification and creation

The order clarification phase is initiated when an order has been received and identified as M3. The first activity of this phase is the assigning of personnel to work with the order. This is done by the Team manager of operations (TMOP) and the Coordination responsible, production (CRP). The TMOP assigns the Order owner (ORO), the Process responsible (PR) and the Automation responsible (AR). He/she also contacts the Technical Editor (TE) and assigns an Automation Designer (AD) if needed. The ORO is from now on the one in charge of driving the order through the process, while the TMOP remains as support and supervisor. The CRP assigns the Documentalist (DS), the Operators (OP), the Process designer (PD) and the Test responsible (TR).

The ORO should as soon as possible after being appointed go through the order form and check to what extent it is complete. In most cases there is a need to have a so called 'Technical clarification meeting' where ambiguities are handled. After this the Sales responsible (PSM, SSMB, SSML, SSMU, hereafter were going to use the common abbreviation SSM) is responsible for sending a '*Confirmation of order received*' to the Market Company (MC). According to the directives this document should be sent within three days after the order has been received and until the order has been clarified the *delivery time* is "frozen". This means that time to delivery will be extended with the number of days spent on clarifying the order. The 'Confirmation of order received' could be of three types: "*Green*" – the order is accepted; "*Yellow*" – the order has to be clarified and "*Red*" – the order is not accepted.



When the order has been clarified it is checked for deviations from standard modules by the AR and PR. These deviations should be noted in the *Production planning protocol* and the *Test report*. Next, ORO creates and configures the sales order in the ERP-system (SAP R/3). The Sales manager does a cost calculation and further calculates budget costs, transfer price and gross margin. When all the planning has been done the ORO should schedule a *Production Planning Meeting (PPM)*. When receiving the invitation to the meeting the AR, PR and CRP can start their preparatory work with the order.

Depending on the order the ORO decides/recommends if the *BoM (Bill of materials)* needs to be ready before the PPM or not. For a typical order this is the case.

Technical specification phase
When the order is clear, the order team needs to design the BoM, the technical purchase specification and the routing and allocation of materials. All these should be ready prior to the PPM where the planned dates for the different required activities downstream in the process are decided.

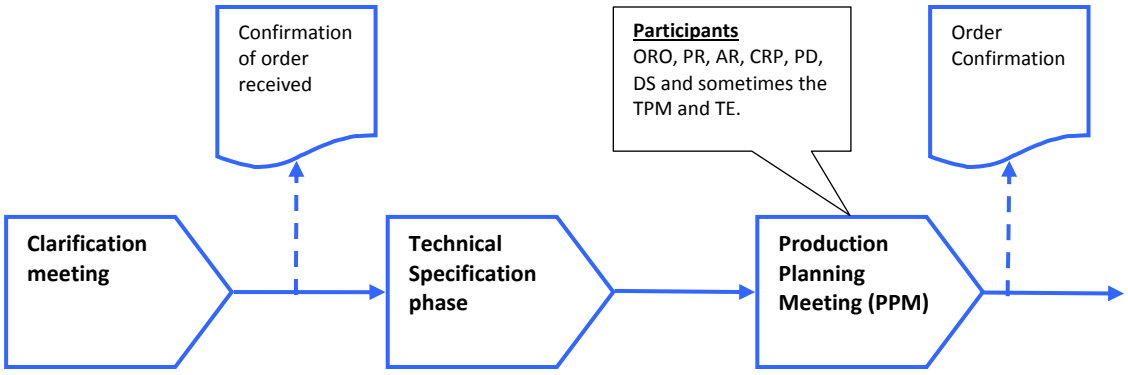
PR has to create the *product configuration* which specifies when different parts of the module/machine are in operation along with operation capabilities, temperature programs etc. The PR is also in charge of making the *technical specification* which is the overall description of the machine. After the technical specification is done, the PR needs to make a *flow diagram* of the module and specify the *major components* of the order (e.g. heat exchanges, control panels, pumps etc.) to enable the purchasers to proceed with their work. These components are ordered from TPPC, and are not included in the BoM.

From TPPC, PR also orders the design of the tube heat exchanger. PR discusses the design informally before sending a requisition to Purchasing. The Purchase responsible (PUR) makes the actual order and receives a confirmation within three days. The design is then delivered to PR.

PR is further responsible for creating the order BoM. This list should contain all specified materials that are going to be used in the production of the new machine or in the upgrade of an old one. The BoM creation is a very important activity since as much as 70 % of the value of a machine can be constituted of the materials. When the BoM is created PR uses it to create what is called an *Item list* in R/3, which is used to keep track of the location of the components during the production phase.

Based on the Item list and the flow diagram, the AR makes the control panel specification. The control panel is the hardware used for monitoring and steering the module. The control panel can be done in two ways, either by specifying the deviations from the standard model or by making a new complete specification. AR holds an informal dialogue with TPPC regarding the specifications. He/she then formalizes them and sends them to PR who sends them to Purchasing.

The last step in the technical specification phase consists of PR making a preliminary *assembly layout drawing* which will be included in the installation and technical manual sent to the customer.



Production planning meeting (PPM)

The PPM is often referred to as the "kick-off" of the order because during this the planned dates for all the downstream activities are decided on. The decision should be based on what is needed in order to fulfil the customers requested delivery date. The meeting should be participated by ORO, PR, AR, CRP, PD, DS and sometimes the Technical Product Manager (TPM) and TE (Technical Editor). The prerequisites for having the meeting is that the MC have clarified all ambiguities in the order, that the sales order has been created in the R/3 system and that the order BoM is ready.

Two scenarios can occur during the planning meeting depending on the degree of customization of the product.

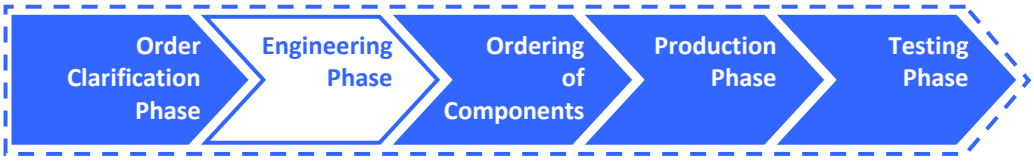
Scenario A
The orders of products of type 1 and 10 (which are more standardized) generally just need one planning meeting.

Scenario B
The orders of products type 100 (which are more customized) normally need more than one planning meeting. During the first meeting materials with long lead times are decided on. In order to complete the BoM more engineering is then needed.

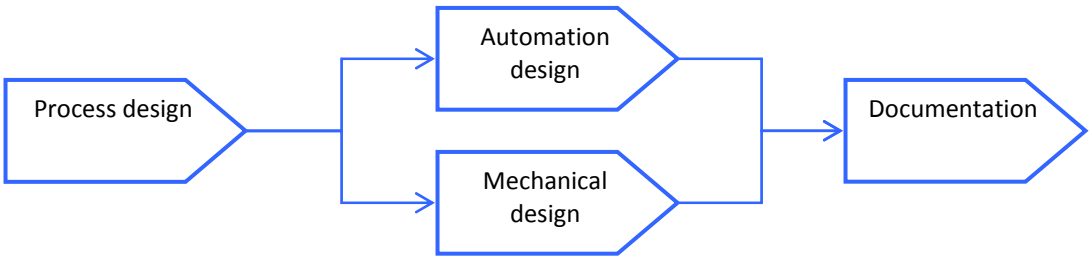
It is the ORO's responsibility to check and confirm the configuration, to confirm the transfer price, to make sure that the preliminary production plan is in order, and to write the '*Production planning protocol*' *(PPP).* In the PPP the time schedule of the different required activities should be defined. The CRP has prepared the production planning and the material requirement planning (MRP) for the components of the machine. These dates are automatically calculated based on the delivery date, and they are said to follow *the route.*

After having this meeting, the ORO must send the '*Order confirmation*' (OC) to the MC, which specifies the order identity number and serial number, characteristics of the module, terms of delivery, time of delivery, the total transfer price, terms of payment, etc.

4.2.3 Engineering phase



Following the PPM is the engineering phase. The PR creates a process design, which is input into the automation design done by the AR and the mechanical design done by the PD.



Process design
The process design requires as input a complete process specification which includes the *technical purchase specification*, the *assembly layout*, the *flow diagram* and the *Item list*. When these documents are ready, the PR can proceed in making the *functional documents*. The functional documents are the basis for the programming of the PLC (Programmable logic controller) system and include explanatory diagrams and operating instructions.

The PR also has to put together the 'Installation Data'-binder, which helps the commissioning personnel during the installation of the equipment at the customer's site. AR provides all the relevant information regarding the electrical documents. ORO then delivers the binder to the customer at the latest five weeks before the equipment is sent.

The PR is in charge of adapting the documents used when testing the equipment (test report and process parameter list) to make sure that the test verifies the characteristics requested by the user.

Automation engineering/Programming
In order for the AR/AD to start working with the design of the automation program he/she needs the documents created by the PR (*flow diagram*, *technical specification*, *the Item List* etc) as well as an approved order. The AR starts with creating the *design basis for the control panel*. When the AR or the AD has this, he/she can start with the adaptation of the software for the machine. The adaptation of the software is done using the program template specified for the module. Once the software has been adapted, the AR/AD designs a desktop test that when passed should guarantee that all the parts are working as intended. If a fault is found in the program, it should be corrected at this point.

Later, the AR prepares the PLC-parameter list that should be checked during the test of the machine. After the machine has been tested in the workshop the PR and the AR adapts the list sent to the commissioning test.

Mechanical design

The mechanical designing includes converting process specification documents into drawings used when assembling the machines in the workshop and at the customer site (see Figure 4-5. The relevant documents include the *assembly material selection list* (which is a specification of all the materials that can be selected based on the product characteristics), the *process specification documents*, *the technical specifications* and the *product configuration* (a description of the customer's products' production characteristics). When all these documents are available, PD (or in some cases PR) create the 3D model of the machine in a CAD-system. When the specification of the materials used is ready, this information has to be entered into the sales order BoM. When this is done it can be transformed into a production order BoM.

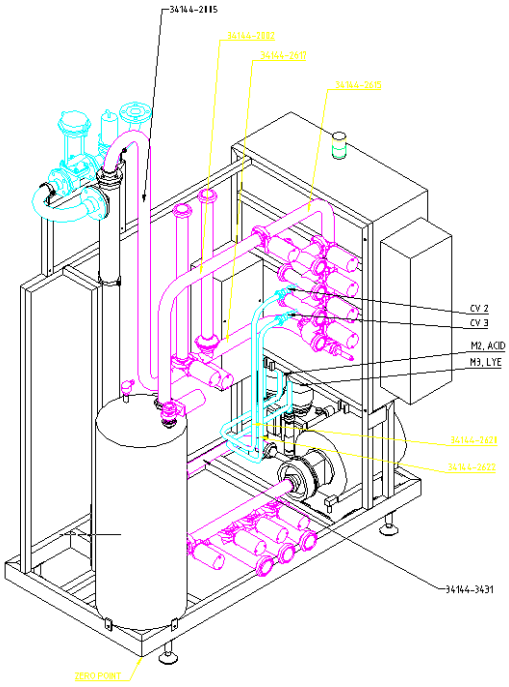


Figure 4-5 Example of mechanical drawing

If the ordered product has deviated from the product templates the design documents in all engineering phases (process design, automation design and mechanical design) need to be review. The purpose of this is to ensure that the design meets the specifications requested by the customer and to identify necessary changes that need to be made to the templates to avoid future problems with the performance of the equipment.

Documentation

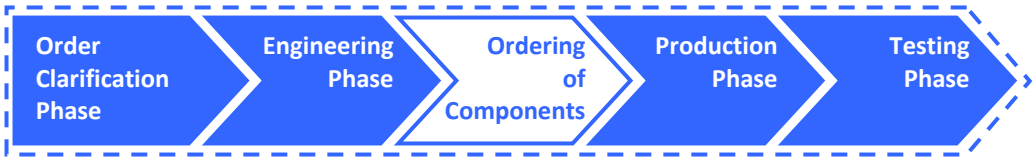
After the different documents are done during the engineering phase, the assembly of the documentation for each order can commence. First the ORO makes a 'Specification for

instruction manuals'. The instruction manuals include an Operation Manual (OM), a Technical Manual (TeM) and an Electrical Manual (EM), which are intended to support the MC and the customer. Then the ORO sends this to the Documentalist (DS).

When relevant the DS contacts the Technical Editor (TE) to initiate the adjustment of TeM and OM for the specific order. The OM, TeM and EM can either be adapted from a previous version or be created from scratch, depending on the customization of the order. The TE produces a draft of all parts of OM, TeM and EM in the Frame Maker software. Then to ensure that the manuals are consistent with directives and legislation they are sent to a verifier for review. Once they have been reviewed, they together with the technical manual input and all the certificates made for the order (Ex. CE-declaration of conformity) are assembled into instructions manuals. The manuals are always done in English, but when a translation is required the DS orders it from TPPC.

Once the documents have been approved, the DS distributes the instruction manuals according to the delivery instructions. Also, DS has to archive the original manual and publish the instruction manual, spare part list and preventive maintenance list on the server. The revised documents after the test, commissioning and upgrade also have to be distributed to the customer.

4.2.4 Ordering of components



After the PPM has been held the 'Sales order' and the 'Production planning' constitute input into the preparation of production. The '*Production order*' is used for reserving resources that are used in production.

Planned cost
The planned order established at the PPM is transformed into a 'firm planned order', which has a fixed time schedule. This is in its turn used for the calculation of the planned cost. The ORO goes through the budgeted cost and in cases where there are ambiguities asks the SSM to clarify. Based on the content of the BoM a planned cost is calculated.

Purchasing
After the PPM the *purchase requisitions* are released and together with the *purchase specifications* they constitute the input to Purchasing. Purchase specifications include components that do not have material numbers. These can include heat exchangers, homogenizers etc. i.e. components ordered internally within Tetra Pak.

R/3 automatically produces a suggestion of what and how much should be bought of each component that has a material number. The purchaser (PU) goes through this list and

checks the content. If it is approved then the requisitions are transformed into orders. For the components without material numbers PU converts the specification into an order in the appropriate system, which is then sent to the supplier. Late amendments to an order and cancellations of orders should be handled by the original purchaser.

Converting the planned order to a production order
The next step is of great importance and has therefore been labelled Tollgate 1 (TG1). To be able to perform it, a number of prerequisites have to be fulfilled (see
Table 4-3):

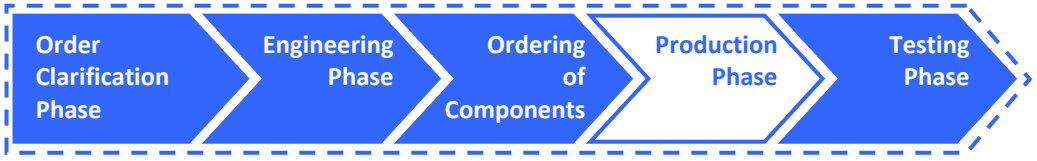
Table 4-3 Required documents for Tollgate 1

Required documents for Tollgate 1
▪ The order is 100 % clarified ▪ The BoM is ready including technical purchase specifications ▪ Routing and allocations of resources are ready ▪ The last planning meeting has been held ▪ All the purchasing requisitions have been released ▪ Purchase orders have been created and sent to the supplier ▪ Costing has been done

ORO makes sure that the purchase orders have been sent and that the delivery dates are correct. CRP converts the *firm planned order* into a *production order* and checks the material availability. When the order has been converted materials can be *reserved* and the order can be *released*.

Goods receiving
When the goods are received they are controlled, marked and placed on the correct place in the storage. Depending on the knowledge of the supplier and the marking of the goods this procedure could be more or less cumbersome.

4.2.5 Production phase



Picking to production
Before the production phase begins the material is picked from the stockroom. Important input to this activity is the *stock reservation* and the *released production order*. The planning of the picking operations is automatically handled by the MRP-function in R/3.

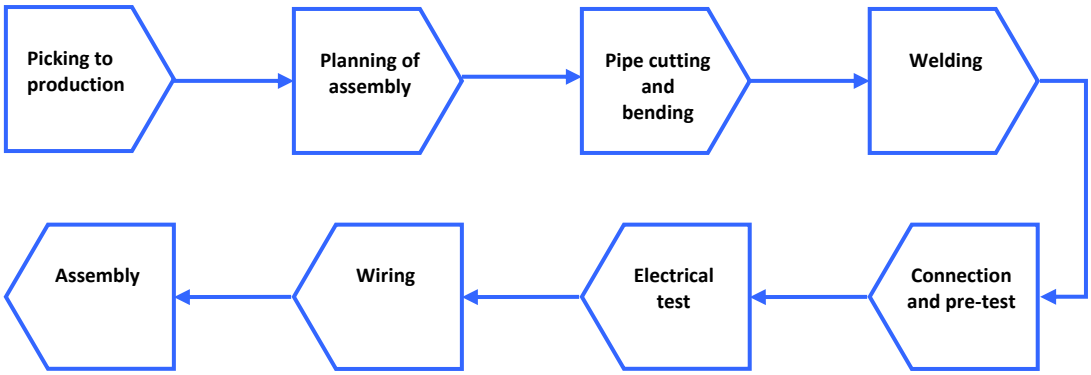
The goods are picked according to the lists and placed on a carrier (e.g. a trolley) which is labelled with production order number and if relevant production supply area identity. The carrier is then placed in a relevant area of production or in a temporary area. Small articles are put in plastic bags marked with material number, while large articles are market

with material number and purchase order number and placed directly on the carrier. The picking is typically done one day before the production activity is started and thereby ready when production is planned to start the following day.

Input
The input to the production is the *production specification*, which includes: BoM, flow diagram, assembly drawings, detail drawings, assembly layout, pipe configuration drawings and pipe bending information. These documents are used in the planning of assembly.

Planning of assembly
The assembly planning is done mainly for making sure that standards and norms are followed, and to issue instructions when manufacturing is needed. The responsible OP should before the start of production have had a meeting with the responsible PD to make sure that the drawings and lists are clear and updated.

The OP then fills in a Shop order, and if needed demand for specific personnel and equipment. Then the production commences with pipe cutting and bending.



Pipe cutting and bending
The pipes are cut according to coordinate lists, cleaned and removed from sharp edges. Bend coordinates are put into the pipe bending machine and when the pipe has been bent it is inspected to ensure that angles are correct and that the pipe holds the accurate quality. The time frame for cutting and bending the pipes is normally one day, and an operator only work with one order at the time.

Welding
The bent pipes are cut, drilled, flanged and welded according to the drawings provided by Mechanical design. Depending on the components that the pipes are combined with, the work order could differ to some extent. Some pipe components go straight to assembly after being welded, while others have to be preassembled, de-assembled and then welded together with other components. For some modules the welding phase is combined with the assembly to the frame. Welding is done for one order at the time and the time frame for completion is usually one day.

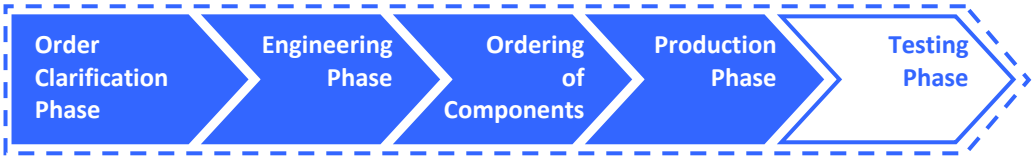
Assembly
The assembling of a machine consists of mounting the components, fittings and pipes in the frame according to the flow diagram and the layout drawings. Assembly is done as the first part in the line and there are two lines for machines with standard frames.

Wiring
After the assembly follows wiring which consists of connecting air, signal cables and main supply. The wiring must follow standards and norms which require that it is done by authorized personnel.

Electrical tests
All modules are tested for electrical safety before pre-test and test.

Connection and pre-test
The machine is connected to water and steam supply according to the flow diagram. The steam equipment is visually inspected.

4.2.6 Testing phase



In the testing phase the machine's functions are tested with water and steam. If the machine is part of a line, often the whole line is tested together.

Input
The main input for the testing phase is a product ready for test. The test responsible (TR) contacts the PR for a briefing on the machine functionality and how and what should be tested. The TR also contacts the AR and gets a briefing on the automation software and receives the software that should be tested. These meetings should be held a few days in advance. To begin the testing the following must be ready (see Table 4-4):

Table 4-4 Input to test

Software	Functional documents	Documents for test
The software should have been desktop tested and all faults should have been corrected. It should further be placed in the correct folder on the server.	The functional documents could be separate or combined into one, but should under any circumstances include; *activation diagram*, *sequence diagram* and *operating instructions*.	The list of document used in testing is long, and contains amongst others the *flow diagram*, *connection data*, *Item list*, *production configuration* and *performance guarantees*.

Preparation of test
The TR informs the responsible OR that he/she is taking over for testing. If tools are used during testing, these should be noted in the test report. Relevant input at this point is assembly documents that instruct how the line should be assembled.

Testing
The testing is performed according to the relevant documents and deviations and faults are noted in the Correction list. This document should also include a signature and the date when the problem is corrected and the man-hours used by TR to rectify the problem. Changes that affect costs and delivery time should be notified the ORO before the changes are undertaken. If changes are made after the testing is finished this must be verified, and possibly followed by a new test. If a problem cannot be rectified during testing because of the nature of the fault or a wrongly specified test protocol then ORO must be alerted and together with AR and PR come up with an action plan. The MC needs to approve that the machine is delivered without certain tests being performed.

When the test is completed this is noted in a document along with (when relevant) changes that need to be rectified by the OP or redesigns that need to be approved by PR. The operator is given a copy of the *Correction list* and is informed about the assembly faults. TR signs the test report and hands it over to the PR along with the Correction list. A copy of the Correction list is (when relevant) handed over to the AR. If the faults affect the overall design (frequent faults on certain products) this is reported to the Technical Production Responsible (TPR) or the ASR (Automation Solution Responsible).

Post test activities
When the test is finalized no deviations and faults should remain. The product is de-assembled and put together with parts that were not used in the test. All loose parts are labelled and all parts are put on suitable carriers in waiting to be packed.

The TR should call for a meeting with PR/AR to give feedback on the test and to hand over design documents for revision (e.g. electrical drawing to electrical designer, software to AR etc.). If critical corrections were made, a meeting should be called with TPM/ASR.

AR/PR and PD should update the relevant documents and store them on the server. DS should be informed about new and revised documents and should update them manually if necessary. ORO should send the documents relevant for commissioning to the MC.

Packing
The first activity when it comes to packing is to prepare the packing list specification. The main idea is that all the parts that are going to be taken out separately from the box should be identified, and thus be on the list. Later, the operator transports the goods to the packing department together with the packing list specification and the order information template.

Once the packing list specification is done and the product is available for packing, TPPC proceed with the preliminary packing list which contains information about the delivery address of the order, the customer, the goods available in each crate and any special packing information.

4.2.7 Summary

Prior to the start of the OFCE process the MC has worked out an agreement with the end customer. The agreement is then specified into an order that is sent to the back office where the OFCE process starts.

The first part of the process consists on developing an understanding of the order's specification and on assigning the personnel responsible of the administration and engineering of the order. After this, the budget cost and transfer price are determined.

The next step consists of creating the technical specification and the product configuration documents necessary for the design of the equipment. These include flow diagrams, specifications of the main components and the order BoM. Subsequent to this there is a planning meeting to clarify all aspects regarding the production of the order.

When the meeting has been held and possible ambiguities have been resolved, the engineering of different components start. This stage includes the making of the process design according to the requested performance, the automation software that is used to operate the machine and the mechanical design used in assembly. At the same time, calculations of the planned costs are made and a purchase requisition for special parts that are not kept in stock is sent to the supplier.

When all the machine specifications are done and the ordered components have arrived, the machine is ready to be assembled. This part of the process includes pipe bending, assembling, welding and electrical wiring. Once the machine is assembled and ready, it can proceed to the workshop tests. These are performed to reassure that the machine follows the specifications and that the software is correctly programmed. When tests are completed and possible deviations from specifications are corrected, the machine is packed and sent to the customer's site. There it is installed and tested until it is working and meeting the agreed performance specified in the contract. Hereby ends the OFCE-process.

4.3 New Milestones description

4.3.1 Background

The New Milestones measuring system was created in 2005 to provide information on the delivery accuracy and internal performance of the OFCE-process. The only metric that already existed was the automatically calculated delivery accuracy (described below as Delivery Accuracy R/3), which at that point was around 40 %. A team was put together to analyse which measurements were needed. The first version of the New Milestones only focused on the production and test phases, but since the results were poor and the conclusion was that the problems could not be isolated to these parts of the process the decision was made to extend the measuring to earlier stages of the process. The version described below has existed since May 2008, but on the request of the MOP's the results have been calculated retrospectively for January to April 2008 as well.

The intention of the introduction of New Milestones was to improve the process, and in the first stage of the development a large number of possible measures were identified. The group that was responsible for this work included the different operational managers in the Food Categories and Competence centres. From the large number of potential Milestones, the ones that were considered to best reflect the process performance were selected.

Unless something else is mentioned the data used for the calculation of the Milestones are the orders delivered between January 2008 and 2009. The total number of orders for this period was 510 and the distribution between the food categories is presented in Figure 4-6 below.

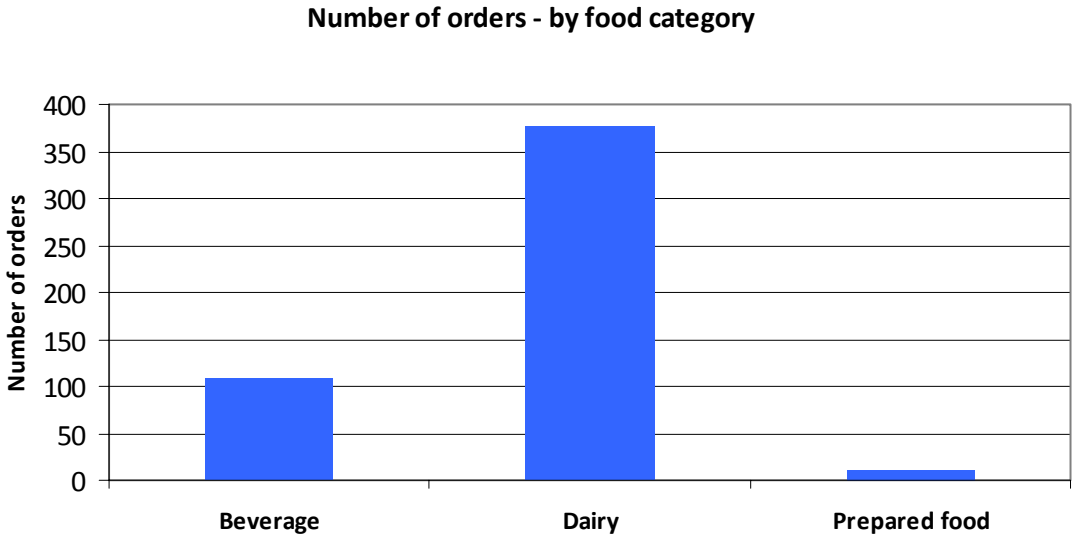


Figure 4-6 Number of orders, by food category Jan 2008 – Jan 2009

In Figure 4-7 below the volume of each machine sold during the given time period is presented.

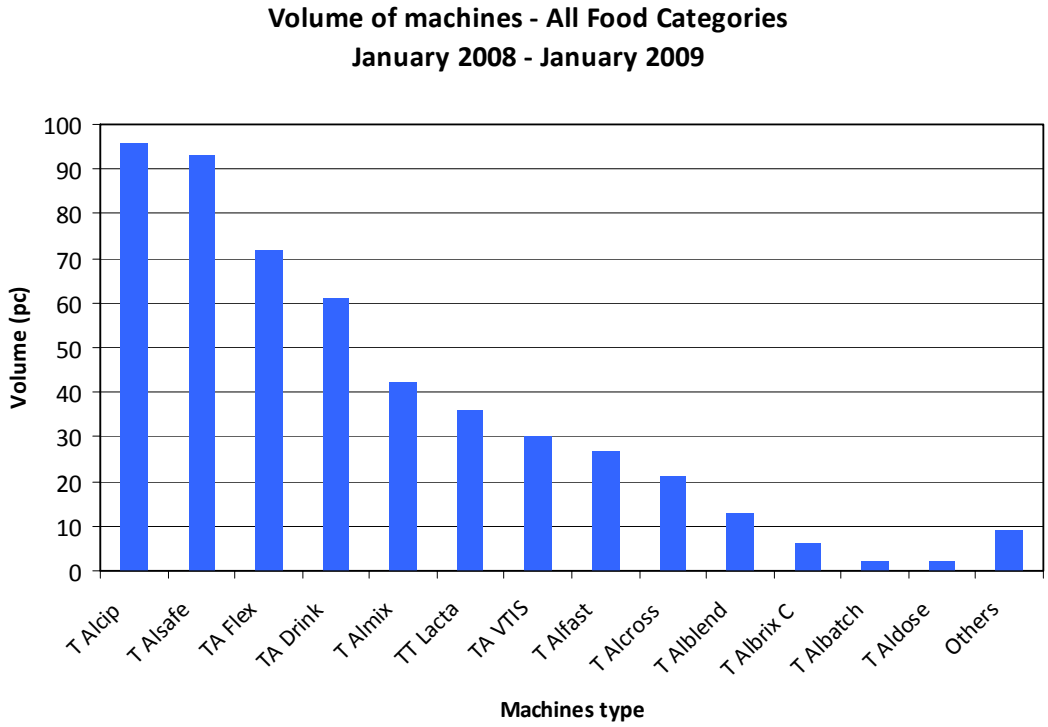
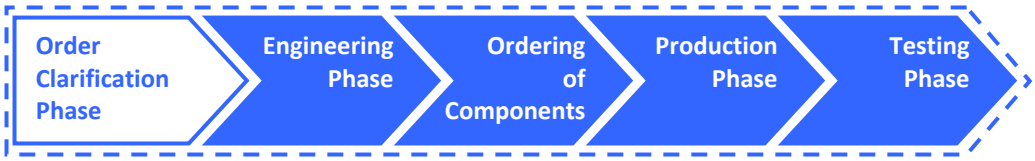


Figure 4-7 Number of orders, by machine type Jan 2008 – Jan 2009

In the following subchapters a description of each Milestone will be given. The Milestones will be divided between the same phases of the OFCE process that were introduced in the previous chapter.

4.3.2 Order clarification phase



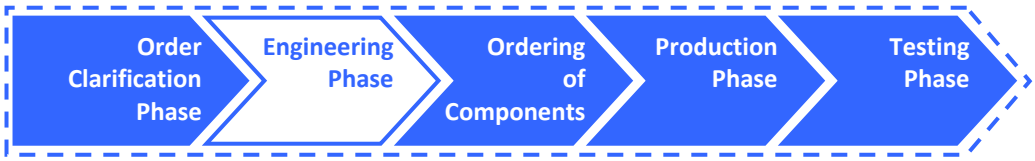
Confirmation of order received

The first Milestone compares the date when the order was received and the date when the 'Confirmation of order received' was sent to the MC. If the reply is sent within three working days of receiving the order, the Milestone is met. The measuring is done by the Manager Sales Support (MSS) that collects the dates from the PPP and the 'Confirmation of order received'-document.

Order confirmation
The 'Order confirmation Milestone' is measured comparing the date when the 'Order confirmation' was sent with the date when the order was received. The order confirmation should be sent within ten working days after receiving the order to be considered as on time. The measuring is done by the TMOP, who obtains the dates from the order confirmation document and the PPP.

BoM ready
The 'BoM ready Milestone' is obtained comparing the planned date for completion of the BoM with the actual ready date. The planned date is decided after the clarification of the order and it is based on the characteristic of the machine and on the delivery date requested by the customer. The planned date is obtained from the PPP and the actual ready date is collected from the *Revision and approval list*, which is an Excel-file used for reporting the ready date of documents. When the BoM is ready before or the same day as the planned date, then the BoM is considered to be on time. The measuring is done by the TMOP.

4.3.3 Engineering phase



Mechanical design
This Milestone compares the mechanical design agreed ready date with its actual ready date. The measuring for 2008 has been taking the reports on whether the mechanical design was ready on time or not, made by the PD in the Mechanical design planning system. From the start of 2009 a new procedures have been used, where the planned date from the PPP is compared with the date reported in the Revision and approval list. The collection of the data is done by the Manager of Mechanical Design (MDM). When the mechanical design is completed earlier or the same day as the agreed ready date, it is considered as on time.

Automation programs
The 'Automation programs Milestone' is the measure used to determine if the designing of the software for the machine was done on time. This measure compares the automation agreed ready date with its actual ready date. The automation planed date is established during the PPM and the actual date is reported by AR into the Revision and approval list. When the automation is completed earlier or the same day as the agreed ready date, then the automation is on time. The data is collected by TMOP.

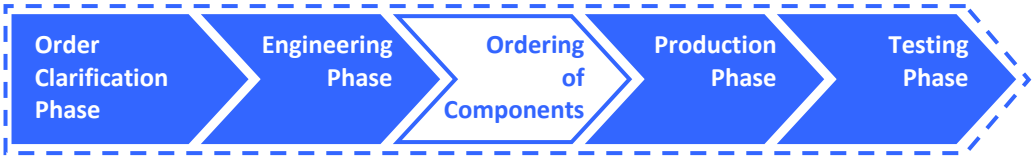
Input for documentation compiling
The 'Input for documentation compiling Milestone' is calculated comparing the planned date for having all the necessary documents for documentation ready with the actual ready

date of the latest ready document. The planned date for the having input for documentation ready is decided in the planning meeting of the order and the actual latest ready date is obtained from the Revision and approval list. When the actual ready date of the last item is reported before or the same day as the planned date then it is considered as on time. The data is collected by TMOP.

Documentation
The 'Documentation Milestone' is obtained by comparing the planned finishing date and the actual finished date of the documentation reported in the system FLOWTS. The reporting of these dates in FLOWTS is done by the DS, but the reporting into New Milestones is done by the MDM. The planned date for documentation ready is taken from the PPP.

Documentation, new machines only
The 'Documentation, new machines only Milestone' is obtained from a file called "Problemrapportering". In this file the DS reports if an order is new or an upgrade and whether it is done on time or not. The planned ready date is taken from the PPP and MDM collects the data.

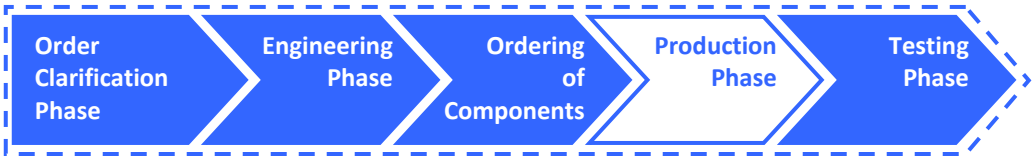
4.3.4 Ordering of components



Material, Confirmed date
The purpose of this measure is to determine the percentage of the components ordered in accordance with existing contracts that are delivered on time by the suppliers. Delayed components can affect the planning of production, especially when they are order specific and delivered Just-In-Time. The Milestone is calculated by comparing the delivery date confirmed by the suppliers with the actual delivery date. Orders that are delivered on the confirmed date ± one day are considered on time. The dates are extracted from the R/3 system by the PU/PUA.

Material, Requested date
This milestone measures the orders for which requested delivery dates are set shorter than agreed upon in the supplier's contracts. It could be that a component that has three weeks delivery time is requested to be delivered in two weeks. The Milestone is calculated by comparing the requested date with the actual delivery date. Deliveries that are delivered on the requested date ± one day are considered on time. The dates are extracted from the R/3 system by the PU/PUA.

4.3.5 Production phase



Pipe bending, Welding, Wiring and Assembly

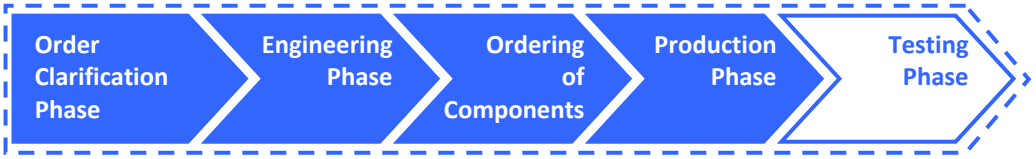
The 'Pipe bending', 'Welding', 'Wiring' and 'Assembly Milestones' are all obtained in the same way. The hit rate is obtained by comparing the planned dates decided in the PPM and the reported actual ready dates. If the operation is reported ready on the planned day, then it is considered on time, and if it is reported on a later date it is considered as late. The planned ready date for assembly and wiring are the same for most products since these activities are done in parallel. The dates are extracted from the R/3 system by the Global Business Expert.

Notification

Division of orders

It should be noted that when sales orders are converted into production orders, they are often *split up into multiple entities* (typically between one and four). This is present for 'Welding', 'Assembly' and 'Wiring'. When for example the 'Welding Milestone' is calculated this has the effect that a sales order having being split into two production orders has twice as much influence on the results as a sales order with only one production order. Further, an order could have different number of production orders in Welding, Assembly and Wiring.

4.3.6 Testing phase



Test

The Test Milestone is obtained by comparing the date decided in the PPM and the actual ready date reported in R/3. If the test is reported ready on the planned day, then it is considered on time, and if it is reported on a later date it is considered as late. The TRs cannot report this date in the system themselves, but have to turn to the responsible OP. The ready date must be reported the same day, since the system does not allow the entering of old dates. The dates are extracted from the R/3 system by the Global Business Expert.

Packing

This measure is obtained by comparing the planned date in the production plan (MRP) done by the CRP with the actual reported ready date in R/3. The packing should be ready before or in the same day as the planned date to be considered on time and the ready date

should be reported the same day, since the system does not allow entering old dates. The dates are extracted from the R/3 system by the Global Business Expert.

4.3.7 Other Milestones

Prior to the presentation of these more general Milestones it is necessary to introduce the dates that are used to determine them (see Table 4-5). All of these dates are collected directly from R/3.

Table 4-5 Dates used in calculations

Dates used for calculations
OrigPlnDt – is the date when the machine should be ready at BU DBF in order to be delivered at the customers' site on their requested date.
OrigCfDisp – is the date that BU DBF tells the MC that they will have the order ready.
PlnDispDt – is the date that BU DBF plans to have the goods ready. (This date should be the same as the OrigCfDisp, however this is not always the case)
ActDispDt – is the date when the machine was ready.

Orders with dated entered
This Milestone shows the percentage of orders that have dates entered in the information system for OrigPlnDt, OrigCfDisp and in ActDispDt. If an order is missing one of these dates, then it is considered as without information.

Fulfilment Customer Request
This measure shows the percentage of times that BU DBF planned to have the order ready on the date requested by the customer. It is calculated comparing the OrigPlnDt with the OrigCfDisp. When the OrigCfDisp is the same date as OrigPlnDt then the customer request is fulfilled. For this Milestone, only orders with dates entered (see above) are considered.

Delivery Accuracy – R/3
This measure shows the percentage of orders that were delivered on time based on the dates entered into the R/3 system. It is calculated comparing the PlnDispDt with the ActDispDt. When the ActDispDt occurs before or the same day as the PlnDispDt then the order is considered on time.

Delivery Accuracy

The 'Delivery Accuracy R/3' is very rigid in its nature, while 'Delivery Accuracy' leaves the option to take certain factors into consideration. This Milestone is obtained after reviewing the reasons why an order was not delivered on time. When an order is completed late due to circumstances considered outside of the control of BU DBF, then the order is considered as on time. These reasons are presented in Table 4-6.

Table 4-6 Reasons for considering an order as on time

Reasons for considering an order as on time	
1	Goods ready but waiting for shipping instructions
2	Goods ready but waiting for inspection ordered by MC
3	Dispatch delayed due to variation order (dispatch date should have been changed but was not)
4	Goods issue missed with one or two days, but the planned and agreed transport kept
5	Goods ready but awaiting coordinated delivery of many orders to the same customer
6	Goods ready for dispatch but put on hold on request from MC
7	Reporting in R3

* Variation order mean that the order has been changed in such a great extent that delivery date needs to be moved forward in time.

However, if the reasons of delay depend on the performance of BU DBF then the order is still considered as late. The reasons for delay are presented in Table 4-7.

Table 4-7 Reasons for considering an order as late

Reasons for considering an order an late	
8	Problems in supply chain
9	OFCE - Design or specification
10	Lack of resources in OFCE
11	Problems in specification industrialized product
12	Customer Management - Problems in sales order (customer understanding)

The target for this Milestone is set to 95 % or better. This target has been set by the Operations Director based on experience and knowledge of the market. High delivery accuracy and a short delivery time are important means of competition, even though the most important mean of competition is superior quality.

4.3.8 Summary

The New Milestones measurement system is constituted by the 20 measures presented in Table 4-8 below. For each Milestone the January 2008 - January 2009 (13 months) the average is added together with the standard deviation. Results for each month can be seen in Appendix E.

Table 4-8 New Milestones, average January 2008-January 2009

Milestone	Average	Standard deviation
Confirmation of Order Received	9,0 %	12,3 %
Order Confirmation	17,9 %	10,8 %
BoM ready	50,9 %	11,7 %
Material, Confirmed date	84,0 %	5,6 %
Material, Requested date	72,8 %	4,2 %
Mechanical design	97,3 %	2,2 %
Pipe bending	87,5 %	0,0 %
Welding	20,9 %	18,6 %
Assembly	29,5 %	11,1 %
Wiring	39,5 %	16,5 %
Automation programs	40,5 %	12,4 %
Test	53,5 %	13,5 %
Packing	63,1 %	14,5 %
Fulfilment of Customer Request	90,9 %	7,0 %
Orders with dates entered	56,6 %	15,7 %
Delivery Accuracy - R/3	28,9 %	13,8 %
Input for Documentation compiling	56,1 %	11,1 %
Documentation	66,9 %	13,6 %
Documentation, New machines only	76,4 %	14,5 %
Delivery Accuracy	95,4 %	3,4 %

4.4 World class manufacturing

4.4.1 Improvement teams

The 'New Milestone' initiative is a supportive tool in the work with improvements and depending on the nature of the problems the way of working differs. If the causes of the problems are apparent or easily can be identified, the manager responsible can decide on an appropriate action. If the root causes of the problems and their solutions are not apparent, 'Processing Solutions' have created teams that are responsible for different development areas, so called pillars: WCM Office, Education and training, Cost, Logistics, Quality Maintenance, Planned Maintenance, Safety and Environment, and Early Equipment

When a problem has been identified the appropriate responsible(s) for the relevant pillar(s) are involved. These individuals should put together a team including the employees that they believe can contribute to the analysis and resolution of the issue. All employees and managers are in this respect considered as potential resources. The teams could in some cases even work across company borders (within Tetra Pak) if the problem appears in the interface between these. The cooperation could be handled both through meetings and through remote communication depending on the proximity of the companies involved. One problem with this approach to improvement work is that unless the responsible manager decides that the problem is of priority no initiatives are taken. Improvements in interfaces are especially tricky, since an isolated change on one side of the interface risks to have negative impact on the other side.

4.4.2 WCM initiatives

World Class Manufacturing is a companywide program to improve business performance. The mission of the teams is presented in Table 4-9:

Table 4-9 The mission of the WCM teams

WCM teams mission
▪ Make continuous process improvement part of Tetra Pak culture
▪ Make customer satisfaction the main driver of all Tetra Pak Improvement processes
▪ Support the Tetra Pak effort to become a Total Quality process enterprise
▪ Involve customers and suppliers in the improvement processes

Introduction of lines in the workshop

Since the summer of 2008 the workshop activities are performed as part of a line system, which means that the produced machines are flowing through the workshop. It also means that every order should spend the same amount of time in every activity. Picking is done Just- In-Time, and the 5S tools are employed.

Focus on logistics strategy
To keep track of internal logistics, purchasing and picking a logistics responsible role has been introduced. In a lean company where JIT deliveries and line production are employed the logistics strategy is of vital importance.

Tagging
In the workshop a system called "tagging" is used. When a problem is discovered a tag is written, which states the nature of the problem, the suggested short-term solution, the suggested long-term solution and the responsible of taking action. The tags are then handed over to the tagging responsible. The tagging responsible fills in an identification number, clarifies the description if needed and sends it to the responsible of action in a mail. If the actions are delayed a reminder should be sent, and if still nothing happens, the Director of Operations should be notified. A short term solution should be presented within two days, while a long term solution can be presented later.

Correction List Data
The 'Correction list Data' is a database of all the comments reported in the Corrections lists used in testing, and the equivalent for some commissioning tests. Each entry in the database consists a lot of information including type of fault, time lost etc. A special online tool allows anyone to extract information and statistics in form of diagrams.

Frequency studies
A frequency study of the test of a couple of machines was started some years ago to reduce the lead time. One year ago focus was put on reducing the time lost due to faults found during the test for these machines. In order to determine the possible root causes of the problems during the test the 5 why's-tool was employed.

M1/M2/M3-project
To be able to go through with this project of developing M1/M2/M3 type of orders some important changes from the current situation has to be made. An *M1* order should according to the process description be based around fixed specifications, and thereby bypass the whole first part of the process and go straight into production planning. These orders will be extremely easy to handle since all of them look the same, and thus it is easy to standardize procedures. The *M2* orders would also greatly facilitate the work in the process, since they are based on a limited number of predefined options. This would mean that templates would be easier to develop and the possibilities to reuse work from previous orders would greatly increase. Finally the *M3* orders would be similar to most orders of today.

5 EMPIRICAL DATA - PROBLEMS AND IMPROVEMENT AREAS

This chapter will introduce the problems and improvement areas identified for the OFCE-process and the 'New Milestones'.

5.1 *Process improvement areas*

In this chapter improvement areas are identified based on interviews conducted with managers and employees working in the process, and on New Milestones data.

5.1.1 The need for improvements

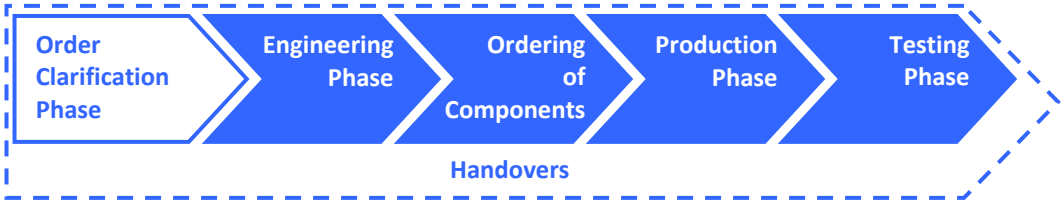
Since the target of the Milestones is to be close to 100 % in order to ensure a good process performance, there clearly exist issues, see Table 4-8. The belief among management is that the high delivery accuracy only can be maintained through the use of excessive use of resources in production and testing. This is confirmed by the data presented in Appendix F comparing planned time with actual time spent on an order. In the 13 month long period 34 513 hours exceeding the planned hours have been reported. If this figure is related to the total number of planned hours during the period which is 154 016 h, the additional number of hours spent is 22.4 %.

If the approximation is made that the hourly rates are according to Table 5-1, the total cost of the additional work amounts to almost *23 MSEK* for the period of 13 months.

Table 5-1 Costs per hour for different activities

Type of work	Cost/hour
Administration	600 SEK
Workshop (Assembly, Welding etc.)	480 SEK
Mech. Design	580 SEK
Process Engineering	700 SEK
Test	960 SEK

5.1.2 Order clarification phase



The order receiving and clarification phase has been identified as a major improvement area. The suggested problems mostly appear in the interface between two geographically separate locations within Tetra Pak, namely between the MC and BU DBF.

Two basic types of problems

In the interviews a problem frequently mentioned is the clarity of the orders. For an order to go straight through the process when received it must not have any ambiguities. The problems related to unclear orders can essentially be divided into two groups (see Table 5-2).

Table 5-2 Problems related to unclear orders

Problems related to an unclear order
▪ The order takes long time to clarify, which delays the start of work and thus decreasing the margin between lead time and delivery time. ▪ The order is still unclear when the work it begins and thus demands changes when the order is further down the stream. These can sometimes be costly.

If a lot of time is spent on clarifying the order, then all succeeding activities are in risk of being late, which then demands extensive resources to catch up. If the order on the other hand is not fully clarified when work is started, there might be reasons for later changes which could cause delays and additional costs.

Sources of issues

Inferior templates and competence

The impression of the interviewees is that most orders need a clarification meeting before the work with them can be started. The questions are of different nature but they are usually related either to customer specific solutions or to that the order form is not filled out correctly. The same questions recur in many meetings and this has been highlighted to the TPM or the PM, who are responsible for the Price book order form. Since the Price book is only reviewed twice a year the same issues needs to be dealt with on several occasions. In Table 5-3 below a couple issues with the order form are described.

Table 5-3 Issues with order forms

From interviews	From an observation of a Tech. Clar. Meet.
▪ In some cases the order forms ask whether the customer wants one option or another (e.g. two or three pumps). Without the proper performance data it is hard for the customer/MC to select the option that best suit their needs. ▪ There is a free text field used for specific requests. Often these are the subjects that need to be clarified.	▪ The MC had selected two mutually exclusive options and missed to fill in necessary options. BU DBF needs to go back to the customer to clarify these ambiguities. ▪ In the clarification meeting some of ambiguities in the constitution of the order form were discussed, but they were not written down. ▪ A solution specific to the market was chosen, but in order to recognize it there was a need for experience having dealt with the solution before.

When an order is unclear and questions are sent to the MC the people assigned to work with the order do as much work as possible without the clarifications. This is a way to move the order further avoiding the risk of rework.

Deviations from the process directives

To construct an order form that eliminates all risks of ambiguities is not an easy task. From interviews and observations it has emerged that this is not the only issue related to order receiving and clarifications. According to the procedures time should be frozen when questions have been sent back to the MC and the additional time spent on clarification should then be added to the delivery date. At the moment this is not always done, and the situation has been even worse in the past.

Another clear deviation from the process description is the negligence in the use of the 'Confirmation of order received'. This is instead handled in a mail or in a phone call. Whether this really has an impact on the further handling of orders is hard to determine, but it under any circumstances makes it harder to track the correspondence with the MC.

Depending on the persons involved either the SSM or the ORO handles the contact with the MCs dealing with matters such as clarifications or other questions. In some cases the questions could even be sent by the PR or AR if they are of a more technical nature.

Scenarios

From saved correspondence the following two scenarios were selected to illustrate the current situation of the clarification process:

Scenario 1 (see Table 5-4) – In the first scenario the questions required for clarification was sent to the MC eleven working days after the reception of the order while the MC managed to answer the question the same day. The order confirmation was sent six working days after the order seems to have been clarified. Comparing to directives the order was seven days late.

Table 5-4 Scenario 1 – Order clarification

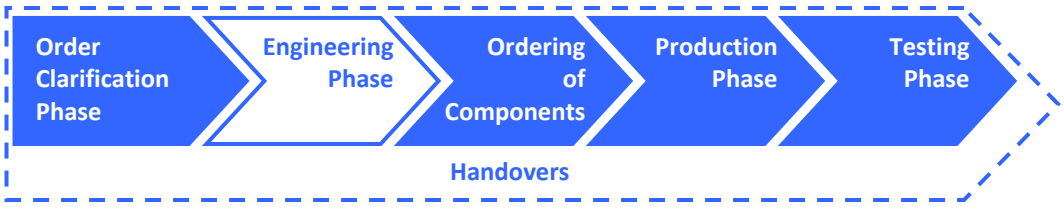
Date	BU DBF, Lund	Market Company	Working days
2008-0X-01	The order is received.		0
2008-0X-18	Questions are sent to the MC about a specific temperature.		11
2008-0X-18		The questions were answered.	11
2008-0X-26	'Order confirmation' was sent.		17

Scenario 2 (see Table 5-5) – In the second scenario the order was handled very soon after it had been received and questions were sent within one working day. The MC took three days to answer the questions and if this time is deducted from the total working days used, the order confirmation would have been sent within the ten days given. If these days are not deducted the order is one day late.

Table 5-5 Scenario 2 – Order clarification

Date	BU DBF Lund	Market Company	Working days
2009-0Y-03	The order is received.		0
2009-0Y-04	Several remarks on the product specification. Some options were eliminated. The order is sent back to MC.		1
2009-0Y-04		MC updates the specifications.	1
2009-0Y-04	Some unnecessary options were eliminated and some specifications required were added. New questions are sent to MC.		1
2009-0Y-05	A reminder regarding the questions is sent to the MC.		2
2009-0Y-06	Some calculations were sent along with a reminder of that additional time used for clarifications will be added to delivery time		3
2009-0Y-09		The questions were answered.	4
2009-0Y-18	'Order confirmation' was sent.		11

5.1.3 Engineering phase



The second area that is in need of improvement is the engineering phase which is an internal concern of BU DBF. The data show that 'BoM ready' is as low as around 50 % which most likely will lead to a delay in the engineering phase. It can be shown that in average the BoM is 19.4 days late, which is likely related to revisions. Since the BoM is a prerequisite for many activities, there are strong reasons to believe that a bad result for 'BoM Ready' will affect the succeeding Milestones.

None of the interviewees has been able to point out any systematic and recurring reason to issues and delays in the engineering phase. The reasons for delays are instead to a large extent order unique. Indications though have been given that the main groups are: *reporting problems/mistakes, high workload, delays to entire projects and changes.*

Workload

PRs and ARs are assigned to orders and are responsible for their area of expertise in form of documents, support etc. Since orders are coming in continuously every PR and AR is assigned to multiple orders in different phases. The number of orders could range from three to fifteen, depending on food category and role. All of the orders are in different

phases, and in the interviews it was stated that PRs and ARs normally concentrate their work on one order until they finish a specific task, e.g. the BoM or the automation program respectively. To illustrate the situation Figure 5-1 below was given:

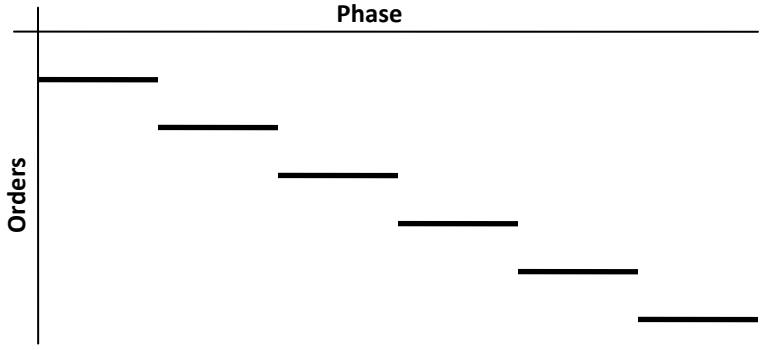


Figure 5-1 Working with multiple orders

Issues related to the workload arise when a problem appears in an order that the AR/PR is not currently working on, and that needs immediate attention. They then need to attend to this issue, thus delaying their work with the new orders and disrupting their work rhythm.

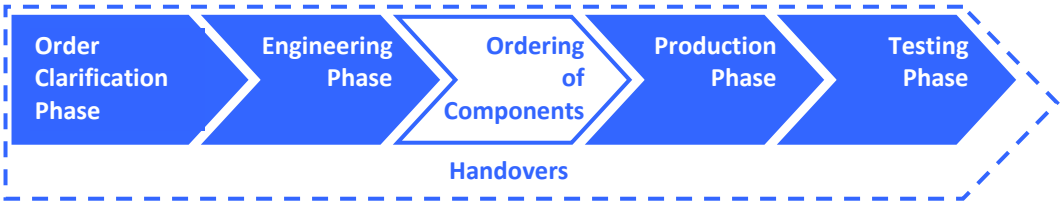
In general most employees seem to have rather good systems for keeping track of what they have to do, and in what order it needs to be done. In situations where a PR is working with many orders, there is a need to switch between these. This can lead to that simple orders where the expected effective time to complete the BoM is 2-3 hours, have a "delivery time" of 3-4 days. For a complicated order, where new material numbers (and its documentation) needs to be handled, the effective lead time for completing the BoM is about 1 workday, while the delivery time is one week. An element that limits the possibility to decrease the completion time of the BoM is that heat exchanger calculations (design) are ordered from TPPC and usually takes at least three days to be delivered.

Changes

A big issue is the handling of changes. Reasons for changes come out of either mistakes or changes in the customer requests. In order to deal with these, a variation order should be issued and which is then handled in a specific process. The extent to which the variation order is used seems to be based on which food category and the people involved. Changes made to the BoM after it has been released are, according to the PRs, tricky to handle and affect a lot of people. This hence creates a clear incentive to stall the release of it until every important point has been clarified.

For the automation engineers, whose work is not commenced until rather late in the process, the changes are frustrating, since they have less time to take corrective actions.

5.1.4 Ordering of components



The third improvement area exists in the interface between BU DBF and their suppliers.

Issues with purchasing

Complicated procedures
A major problem that is pointed out in several interviews is the complicated procedures of ordering materials that have not been ordered before. New materials need to have an article number and this takes several days to fix. This is especially problematic if the material is needed with short notice, and sometime forces employees to work outside the system. This is problematic since the material does not show up in information generated by the system, such as the picking lists etc. These components instead have to be handled by the responsible AR/PR. Even orders between the different Tetra Pak companies need formal orders, even though the discussions and specifications are done informally.

Late ordering
The data in Table 4-8 indicates that the BoM is only reported on time in around 50 % of the cases. Since the BoM is used as basis for most of the purchased components, an attempt was made to determine the effects of a late BoM. The collected data was limited to purchase orders made in January 2009 and included the eleven biggest suppliers for the period January to March in terms of value (see Table 5-6).

During January 2009, BU DBF ordered 913 different components. The eleven biggest suppliers dealt with 428 of these components, which represents 46.9 %. In the following figure the suppliers are listed with name and the type of components they supply BU DBF with.

Table 5-6 The eleven most important suppliers

Supplier name	Type of components
Alfa Laval Kolding AS	Fittings, valves, pumps
Endress & Hauser Consult AG	Instruments
WI-TÖ ROSTFRIA AB	Frames
Tetra Pak Processing Comp. CCP	Panels
Tetra Pak Processing Comp. CSC	Vessels
EMV Stainless AB	Construction details
Outokumpu Stainless Tubular	Tubes
Tetra Pak Processing Comp. CHT	Tubular Heat Exchangers
Alfa Laval Lund AB	Plate Heat Exchangers
Tetra Pak Processing Comp. CHP	Homogenizers
Scanima A/S	Mixer units

Table 5-7 below shows the number of components ordered in January 2009 that were requested by BU DBF with a shorter delivery time than agreed on in the contract with the supplier.

Table 5-7 Number of orders with shorter requested dates

Supplier name	Total number of orders	Shorter requested date	
		Number	Percentage
Alfa Laval Kolding AS	231	113	48.9 %
Endress & Hauser Consult AG	39	19	48.7 %
WI-TÖ ROSTFRIA AB	39	13	33.3 %
Tetra Pak Processing Comp. CCP	34	13	38.2 %
Tetra Pak Processing Comp. CSC	30	11	36.7 %
EMV Stainless AB	13	4	30.8 %
Outokumpu Stainless Tubular*	13	0	0 %
Tetra Pak Processing Comp. CHT	13	0	0 %
Alfa Laval Lund AB	9	0	0 %
Tetra Pak Processing Comp. CHP	4	0	0 %
Scanima A/S	3	3	100%
Average	**428**	**176**	**41.1 %**
*Extra large purchase, since supplier was closing down			

A large portion of the components (30 - 50 %) ordered from the suppliers at the top of the list were requested to be delivered in shorter time than agreed on in the contract. What stands outs is that 50 % of the orders to Alfa Laval Kolding, the supplier with the highest volume, and 33.3 % of the orders sent to WI-TÖ ROSTFRIA had a requested delivery time shorter than agreed. Without the frame provided by the latter, no major assembly can be performed. The average number of orders with a shorter requested date is as can be seen in table above 41.1 %. Out of these only around 60 % are delivered on this requested date.

Issues with deliveries

BU DBF has for all of their standard components developed a sourcing strategy. The ordering of components should be done according to this strategy, which categorizes the products depending on value (cost), delivery time, how it is picked to production etc. This initiative is supposed to ensure that the materials are available when needed in production, but still several issues related to deliveries of components have been pointed out in the interviews (see Table 5-8).

Table 5-8 Issues related to deliveries of components

Delivery issues
▪ The delivery time of panels is too long. These are ordered internally from TPPC, but could be ordered externally. ▪ Suppliers do not always follow the agreed delivery times. ▪ The orders from important external suppliers (especially Alfa Laval Kolding (LKM)) have long delivery time and delivery terms can be changed without BU DBF being notified of the changes.

The Global Process Experts, responsible for among other things collecting data from the system, are at present monitoring the number of missing components. Each order missing components adds one to the total figure for each type of component missing (no matter the actual missing quantity). During the period January 2008 to January 2009, the number of missing materials varies between below 50 and over 250. New components are further added each day (a diagram showing this could be seen in Appendix G).

The data on delivery accuracy, collected from the R/3 system (through what is called Business Warehouse) further confirms the situation. For BU DBF, the average percentage of material for production delivered by the requested date is 70.9 %. The system considers on time as if delivery occurs on the requested date + 1 day. A diagram of delivery accuracy for the last 12 months can be seen in Appendix H.

To determine the relevance of the issues connected to deliveries, an evaluation of the eleven suppliers identified above was conducted. The same source of data was used.

Longer confirmed delivery dates

One issue related to deliveries is when suppliers confirm a delivery time that is longer than what is stated in the contract. In Table 5-9 the percentage of orders for which this was the case in January 2009 are presented. The only orders considered here are those that simultaneously have a confirmed delivery date later than the delivery date requested by BU DBF.

Table 5-9 Number of orders with late confirmed dates

Supplier name	Number of orders	Later confirmed delivery date	
		Number	Percentage
Alfa Laval Kolding AS	231	37	16.0 %
Endress & Hauser Consult AG	39	10	25.6 %
WI-TÖ ROSTFRIA AB	39	7	17.9 %
Tetra Pak Processing Comp. CCP	34	7	20.6 %
Tetra Pak Processing Comp. CSC	30	4	13.3 %
EMV Stainless AB	13	1	7.7 %
Outokumpu Stainless Tubular*	13	0	0 %
Tetra Pak Processing Comp. CHT	13	6	46.2 %
Alfa Laval Lund AB	9	1	11.1 %
Tetra Pak Processing Comp. CHP	4	0	0 %
Scanima A/S	3	0	0 %
Grand Total	**428**	**73**	**17.1 %**
*Extra large purchase, since supplier was closing down			

The share of orders for which this phenomenon is present varies between 16 and 26 % for most of the suppliers with a few exceptions. In the table above (together with Table 5-7) it can also be observed that none of the orders to Tetra Pak Processing Comp. CHT were requested with a shorter delivery time than requested in the contract, but 46.2 % of the orders were confirmed later than the contract.

Longer delivery times

A second issue related to deliveries is when the delivery time is longer than what is stated in the contract. In Table 5-10 the percentage of orders for which this was the case in January 2009 are presented. The only orders considered here are those that simultaneously were delivered later than the delivery date requested by BU DBF.

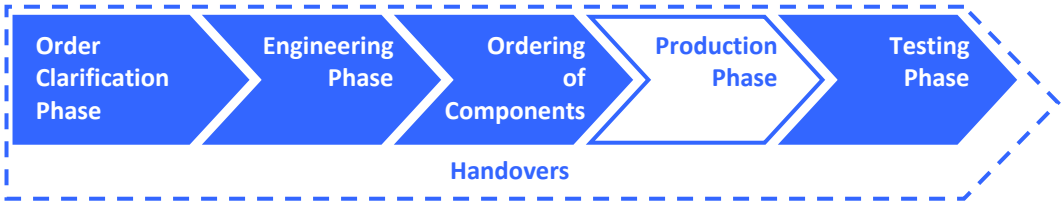
Table 5-10 Number of longer delivery time than in contract

Supplier name	Number of orders	Longer delivery time	
		Number	Percentage
Alfa Laval Kolding AS	231	50	21.6 %
Endress & Hauser Consult AG	39	8	20.5 %
WI-TÖ ROSTFRIA AB	39	13	33.3 %
Tetra Pak Processing Comp. CCP	34	10	29.4 %
Tetra Pak Processing Comp. CSC	30	7	23.3 %
EMV Stainless AB	13	2	15.4 %
Outokumpu Stainless Tubular*	13	0	0 %
Tetra Pak Processing Comp. CHT	13	8	61.5 %
Alfa Laval Lund AB	9	1	11.1 %
Tetra Pak Processing Comp. CHP	4	2	50.0 %
Scanima A/S	3	0	0 %
Grand Total	**428**	**101**	**23.6 %**
*Extra large purchase, since supplier was closing down			

In the table above, it can be observed that for most of the suppliers the goods are delivered late for 20 to 35 % of the orders, or in average 23.6 %. This means that almost one of every four orders needs to be re-planned due to late deliveries of material. If a late delivery occur for the same order for which the confirmed delivery date is later than agreed in contract the production plan needs to be redone twice.

Outokumpu Stainless Tubular and Scanima A/S were the only suppliers that delivered all the orders according to the contract. However, all the components ordered to Outokumpu Stainless Tubular were ordered with 101 days in advance which is much longer than the delivery time that appears in the contract.

5.1.5 Production phase



The fourth improvement area is once again internal and focuses on the production planning and other matters related to production. The issues related to production are identified through interviews, data and observation.

Changes to the orders

In the interviews with people involved in planning of production it was mentioned that almost every order is affected by some type of change, which means there is need for re-planning. Since a lot of people and systems are involved, these are hard to handle. An analysis made internally in March indicated that there were a number of orders that were not in the daily workshop planning, though existing in R/3.

To get an overview of why the changes were made, a study was performed between May and December 2008 by the people responsible for the production. The changes made after the MRP had been done were arranged based on product and reason. The total number of changes made was 735 in total and the changes were spread among the reasons according to Figure 5-2 below.

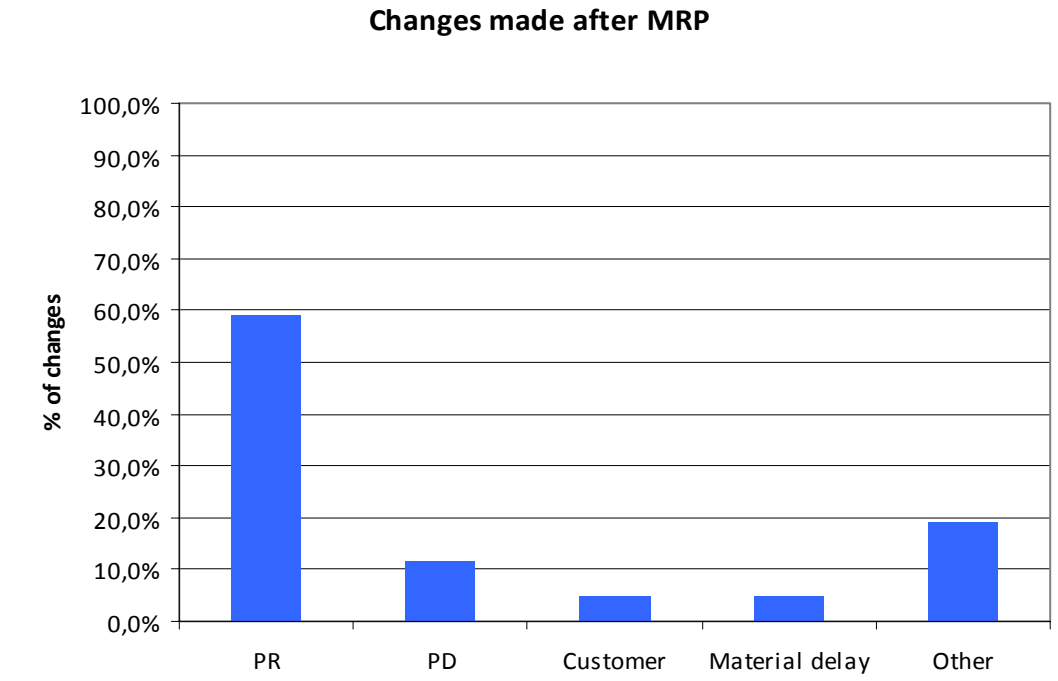


Figure 5-2 Number of changes made after MRP, by type.

The dominating reason is changes made by the PR, while changes in planning due to customer requests and delayed material are both less than 10 %.

If a division instead is made between products, the following results are found (see Figure 5-3).

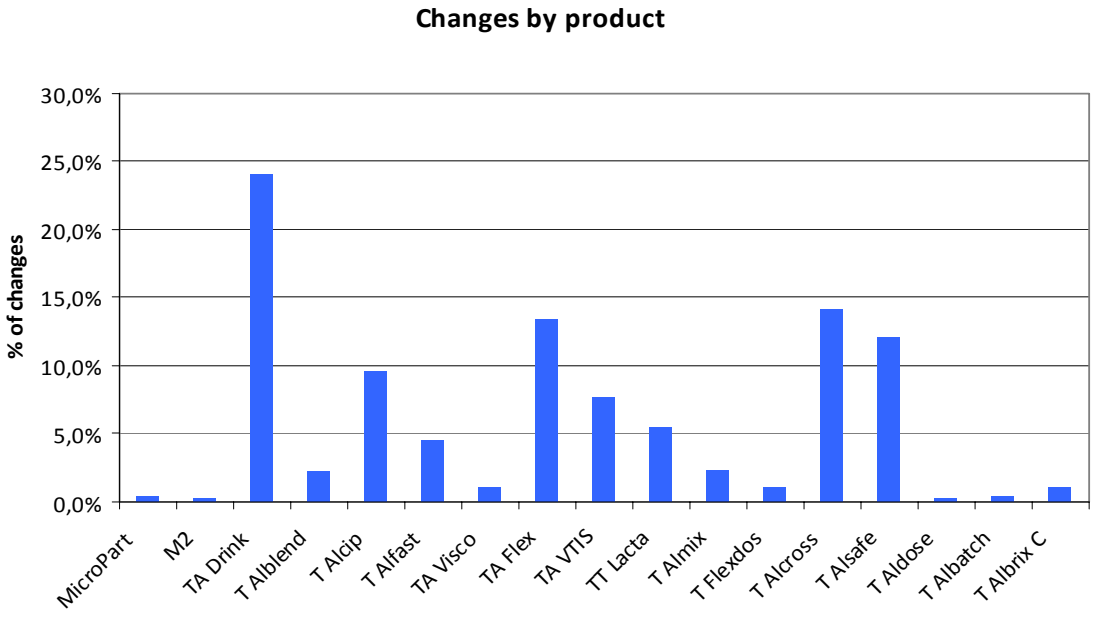


Figure 5-3 Number of changes made after MRP, by product.

From this figure it is evident that some of the products have a considerably higher change frequency than others. The TA Drink, TA Flex, T Alcross and T Alsafe together make up more than 63 % of all the changes.

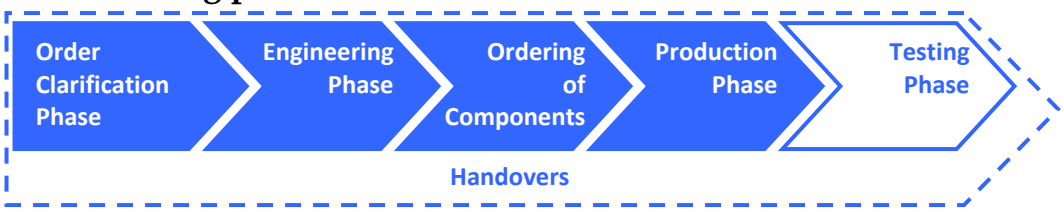
Levelling
Several of the interviewees mentioned a fairly new feature that has been added to the production planning called levelling. In the planning, a period of time (usually around 7 working days), is put between the delivery date and the finishing of the last operation. This period of time does not include any activity; and should primarily be used when an order needs to be postponed due to lack of capacity in the workshop. Since all workshop activities are supposed to be performed in a sequence, the whole sequence should be moved to where it can be fitted in. The levelling can also be used for compensating for delays in delivery, or minor delays in the process. At the moment this function has not been put to full use.

Capacity
In the interviews it has been mentioned that the capacity seems to be to low in Welding compared to the following parts of the process, thus making it a bottleneck of the production. Many of the welders are very experienced and are often helping out in assembly when needed to have an order ready on time. At the same time, because of the level of experience required it is often hard to bring in consultants to help out with welding. This makes it hard to catch up, if fallen behind schedule.

Picking of the components
From interviews it was identified that a concrete problem related to picking is that all components are put on one single carrier. This mean that time has to be spent on searching for material that is needed on the relevant station.

A simple way to observe delays in production that has not been re-planned in the R/3 system is the number of carriers with picked material that are being put in the workshop area. Since the date of picking is based on the planned dates for the workshop activities in R/3, unless the orders are re-planned when delayed the material put on trolleys will be ready several days before the activity can start.

5.1.6 Testing phase



The fifth improvement area is the testing phase, where test engineers should interact with designers, engineers and operators.

In the interviews it has been mentioned that the MCs often points out that the quality of the delivered equipment is too low and that they question if it has been tested at all. The reasons behind this can be many, but below are a couple problems that affect this phase of the process.

The automation program is not always desktop tested
For most of the machines the software is tested in the testing workshop, with a few exceptions that are tested already in the panel workshop. If the program is downloaded in the testing workshop, this provides experience to the tester that should be able to perform the same task at the customer's site. The problem as some interviewees have pointed out is that the automation program is not always desktop tested by the AR before it is uploaded on the server. This means that problems that should have been caught in these tests are instead discovered in the workshop test.

The test guidelines are not up to date
Interviewees have also mentioned that the test guidelines are not up to date, and are not streamlined between the food categories. This task lies upon the TPM and product development.

TR does not always call to a preparatory and a follow up meeting for the test
Another issue that has been pointed out is that the TR does not always hold a preparatory meeting and thus misses the opportunity to ask questions regarding the specific properties of the product they should test.

The data in Table 5-11 below are based on the test reports, and shows whether the preparatory and follow-up meetings have been held or not. The trend is that the frequency is increasing but is still far from 100 %.

Table 5-11 Meetings between TR, AR and PR

		Meetings with AR		Meetings with PR	
		Before test	After test	Before test	After test
Year	Total	% Meetings held	% Meetings held	% Meetings held	% Meetings held
2005	205	0%	0%	0%	0%
2006	341	42%	28%	39%	24%
2007	452	66%	53%	61%	48%
2008	428	67%	64%	66%	61%
2009	99	72%	67%	75%	69%
In total	**1525**	**52%**	**44%**	**50%**	**41%**

Tests are not rescheduled when needed
In the interviews it has been mentioned that the tests are not rescheduled when needed. Since this induces cost both for personnel and facilities, this should be avoided. This can be connected back to the issues mentioned in the production planning phase. If the delays

are handled in R/3 there is no good way to keep track of when testing needs to be rescheduled.

Time lost during the test

The Correction List Data is a very powerful tool when it comes to improving the products as well as the ways of working but the question is whether it is being used or not. When comparing the total number of faults reported with the number for which actions have been taken, the picture that forms is that this is not the case. In early May 2009, data from 2005 till present amounted to 25 258 entries, whereof 18193 were made in Lund. This could be compared with the number of reported corrective actions taken, which where 913 in total and 770 for Lund. Percentagewise this translates to 3.6 % in total and 4.2 % for Lund. One should perhaps not draw too many conclusions from this, but it is obvious that an available and long developed tool is to a large extent left unused.

Time lost by machine

If the time lost is summed up for each machine, it gives a good view of which machines are most difficult to engineer and produce. The data used to calculate the following results correspond to the period between January 2008 and the beginning of May 2009, and tables with full results can be found in Appendix I. Table 5-12 below presents fourteen machines that together represent more than 80 % of the time lost due to faults in the test and more than 85 % of all the faults identified during test. The table shows the average number of faults and the average time lost per machine. The machines are ordered based on the total number of hours lost in test.

Table 5-12 Faults and hours lost per machine

Module	Number of faults per machine	Time lost per machine (hours)
TA VTIS 100	39.8	42.8
TA Flex 10	13.3	13.2
TA Drink 10	15.8	13.8
T Alsafe LA	7.2	6.5
TA Drink 100	23.7	21.5
TT Lacta 100	21.8	21.3
TA Flex 100	17.8	17.8
TT Lacta 10	10.5	10.1
TA VTIS 10	16	16.1
T Alcip 100	4.6	5.1
T Albrix	28	23.7
TA Visco 100	26	22.6
T Alcip 10	3.3	2.1
TA Flex 1	8.6	9.8

From the table above the reader can observe that the time lost for the TA VTIS 100 in average 42.8 hours per machine. This figure is almost the double of the time lost for the

runner up in this list. What is remarkable is that even though it is far from the highest in volume, it is still the product that is responsible for the biggest total time loss in testing. One should also note that products with higher volume such as TA Drink and TA Flex are responsible for considerable time losses as well, ranging from 13 up to 21.5 h in average per machine.

Time lost by fault type
If the number of fault and time lost instead are summarized for each fault type, the result is Table 5-13 below.

Table 5-13 Number of faults and time lost per fault type

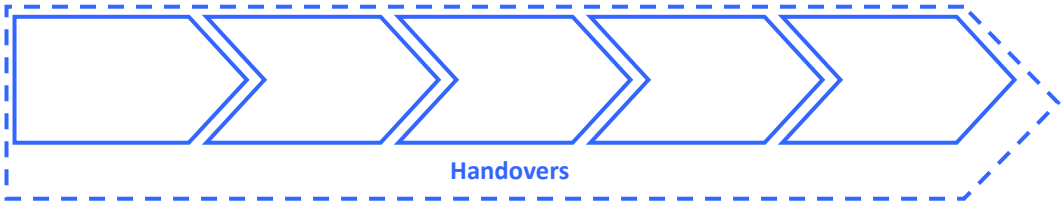
Type of fault	Faults identified in test		Time lost due to faults		Average (time lost / fault)
	Number of faults	Percentage	Sum of time (hours)	Percentage	
Automation	1963	37.4%	1847	34.9%	0.9
Mechanical assembly	1175	22.4%	667.4	12.6%	0.6
Delays	89	1.7%	602.6	11.4%	6.8
Electrical installation	865	16.5%	598.3	11.3%	0.7
Process	363	6.9%	463.5	8.8%	1.3
Component – process	274	5.2%	392.4	7.4%	1.4
Electrical panel	280	5.3%	375.3	7.1%	1.3
Other faults	233	4.4%	343.7	6.4%	8.4
Total	**5242**	**100 %**	**5290.1**	**100 %**	**1**

As seen in the table above around the 35 % of time lost during test are from faults related to automation. The reason for having a desktop test is motivated by this. Next in the list with 12.6 % is faults related to mechanical assembly, followed by delays and electrical installations. These four fault types represent around the 70 % of the time lost during the test.

The occurrences where delay is presented are relatively few, but when they occur the average time lost is significantly higher than for any other type. 6.8 h represents almost a working day. Delays are usually related to delays in either assembly or automation. The four most common fault types from the table above can be split up into sub-faults. This can be seen in Appendix I.

A good initiative has been undertaken by TPM, ASR, the Product Manager (PM) and the Process Expert, for the TA Drink. Here monthly meetings are held to work with the improvement suggestions from the Correction List Data, which when applicable are turned into design changes. A list with problems reported and the actions taken are then distributed to people involved with the product. Out of the 770 corrections reported in the Correction List Data for Lund, this group has contributed with 25.

5.1.7 Handovers



The sixth and last improvement area focuses on a problem that is occurring throughout the process, which is related to handovers. What has been mentioned by several of the interviewees is that the *number* of handovers sometimes cause problems, and in several cases seem to be redundant. Six apparent examples of this could be found.

Clarification of the order
The clarification of the order can be handled in a number of different ways, depending on the persons involved. Sometimes clarification questions are sent through the SSM, who already have done most of his/her work on the order. The SSM is furthermore sometimes reluctant to go back to the MC with questions after agreeing on that the order looked alright.

Ordering of the control panel
The specification of the control panel is done by the AR who contacts and discusses the construction with the responsible people at TPPC. The actual transfer of the order into R/3 on the other hand is done by the PR, while the ordering is handled by Purchasing. Both AR and PR think this arrangement is peculiar and that it causes extra work.

Ordering of the other major components from TPPC
Another seemingly peculiar handover occurs when PR specifies the major components that are ordered from TPPC. Usually there is an informal dialogue between PR and TPPC deciding on what is needed for the particular order, but the ordering is then handled by Purchasing.

Production planning
After the PPM the production planning for the order, made in Excel by the CRP, is transferred to the Production planner, who plans the production workshop both in an Excel-file and in the system RETAIN. If the original planning made by the CRP does not fit into the main schedule, it is updated and then put into R/3. Finally the planning is put into the daily planning for each operation in production, which is administered by the daily planners in the workshop. The daily planning is based around the planned dates in R/3.

Downloading automation program
There seems to be confusion surrounding the downloading of the automation program to the control panel in terms of when and by whom this should be done. The two alternatives are to download it in the panel workshop or in the test workshop. In the process

description for TPPC there is no mentioning of it and in the BU DBF process description it only says that the TR should contact the AR for a briefing of the automation system and to receive the test software. The ARs only put the program in the correct folder on the server and it is up to the test engineers to download it.

Documentation
The 'Input to documentation Milestone' is intended to measure the handover between BU DBF and TPPC. That this in average is around 50 % indicates that Central documentation will have a rather hard time completing the documentation on time. Since a couple of the documents needed as input are not finalized until after test, then delays here are very likely to result in delays in documentation. In some cases the DS needs to *hunt down* the documents.

5.1.8 Summary

The OFCE-process contains a number of improvement possibilities and not finding an efficient way to deal with them approximately costs almost 2 MSEK per month. The issues to a large extent exist in the interfaces and handovers between functions, where both sides has a responsibility and an interest to contribute to a better solution. The improvement possibilities does not only cover the work conducted in the process, but also the systems and documents that supports it. Some of the issues can be connected to templates that are not up to date and some to the process not being followed. In some cases there seem to be redundant work being carried out, caused by an inefficient process design.

5.2 *Measuring problems*

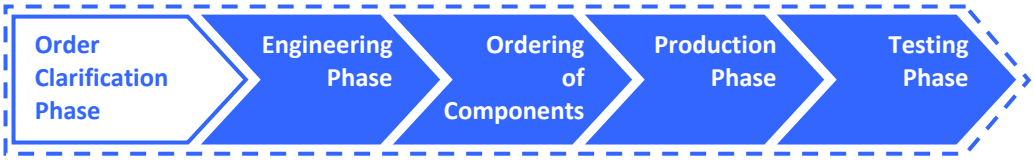
Even though the results given by the New Milestones measuring system indicates problems in the process, the measuring system itself is not without flaws. To be able to fully understand an estimate the impacts of current process deficiencies it is of vital importance to have a reliable measuring system.

5.2.1 Measurement design

This section will touch upon areas where the measurements fail to reflect the process performance. Observe that some numbers are based on available data (see definition below).

Available data – means that orders where information is missing *are not* considered.

Order clarification phase



Confirmation of order received

The first Milestone shows the worst average result of all. The figures presented in Table 4-8 as well as reflections from some of the interviewees indicate that this is related to a mismatch between the measure and the working procedures rather than a poor performing process. The mismatch lies in the fact that Milestone is related to the sending of certain form (green/red/yellow note) which is seldom used. The applied practice is instead to confirm the order receiving through mail or by phone depending on the persons involved. If a mail is sent, and not saved to the proper folder or a phone call made it is very hard to determine when these activities were performed. For available data approximately 63 % of the times the reply is sent on time.

Order confirmation

The process states that the order confirmation should be sent within ten working days after the order has been received and the 'Order confirmation Milestone' is intended to follow up on this. The ideal case involves a clear order that goes right into the process, and for these the target of days is reasonable. The reality involves a large variety of orders, where some are far from clear when received. The directives state that an order should be 'frozen in time' when questions are sent to the MC. This is not considered in the measurement system.

If an order is treated according to directives and the MC takes several days to answer the outstanding questions these days are not added to the date where this activity must be complete. Below Figure 5-4 is illustrating the number of days from the receiving of an order

till the sending of the order confirmation. Observe that this is calculated for orders where data is available and that the days are working days.

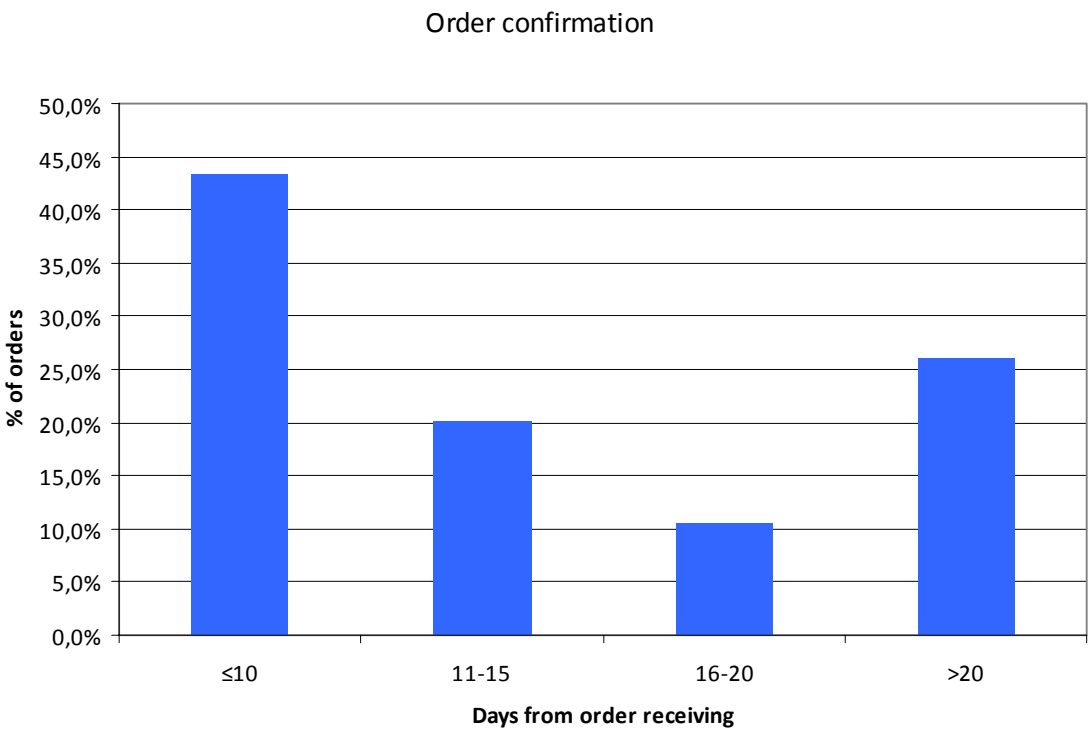


Figure 5-4 Days between order receiving and order confirmation Jan 2008 - Jan 2009

The 20 % of the order confirmations that are ready between 11-15 working days are only a couple of days late, which motivates that the design of the measurement system should be addressed. More than 25 % of the orders for which data is available are not confirmed within 20 days of receiving the order. This could partly be explained by the fact that for the orders where two planning meetings are held, the order confirmation is sent after the second planning meeting. The products for which this is the case is TA VTIS, TA Flex, TT Lacta families, and for other products with special options.

BoM Ready

The BoM should, in a majority of the cases, be ready before the PPM which should be held ten working days after the order has been clarified. The 'New Milestones' on the other hand compares the planned ready date of the BoM reported in the PPP with the reported ready date in the Revision and approval list, where the former often deviates from the ten days mentioned before. In interviews the indication was given that in most cases the priority when it comes to the BoM is to have it correct rather than on a specific time.

From orders with available data Figure 5-5 below is constructed. It shows that 65.2 % of the orders are completed on decided date or before.

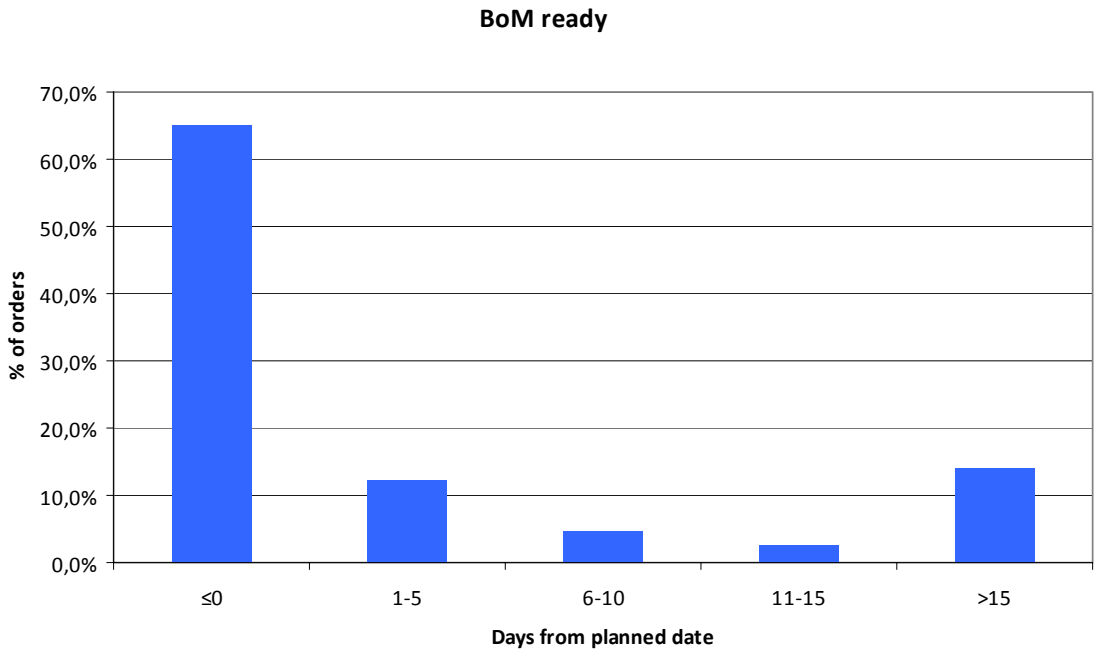
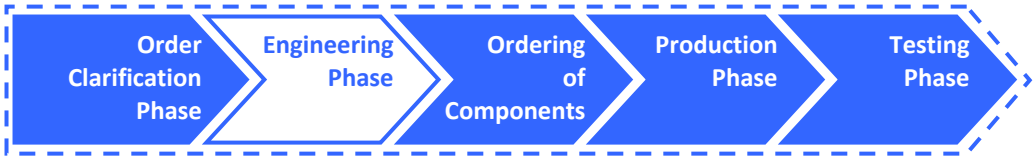


Figure 5-5 Ready day of the BoM, Jan 2008 – Jan 2009

Engineering phase



Automation program

The 'Automation program Milestone' planned ready date is set five working days before the testing starts and the program needs to be ready. This means that programs completed within these five days, will affect the Milestone, but not necessary the process performance. From the available data the histogram below can be put together (see Figure 5-6 below).

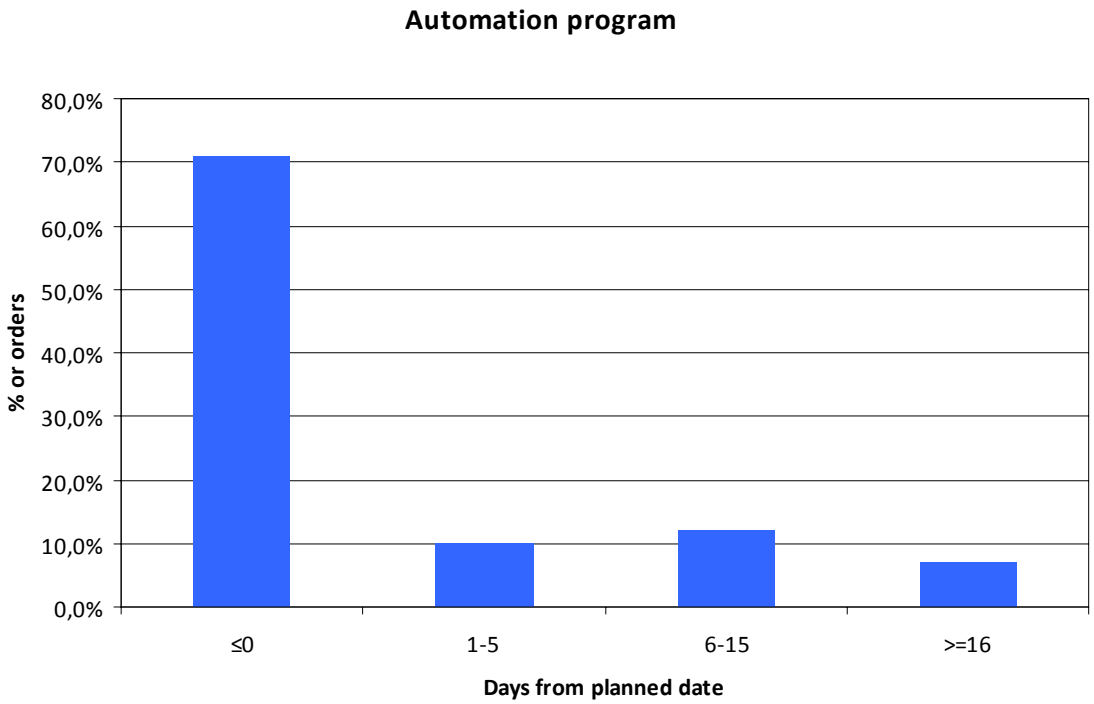


Figure 5-6 Ready day of the automation program

From the histogram it can be seen that approximately 70 % of the orders are completed on time, while another 10 % are ready within five workdays after the deadline. The five days are intended to be used for downloading and test the program in the panel workshop, but this is not done for all machines.

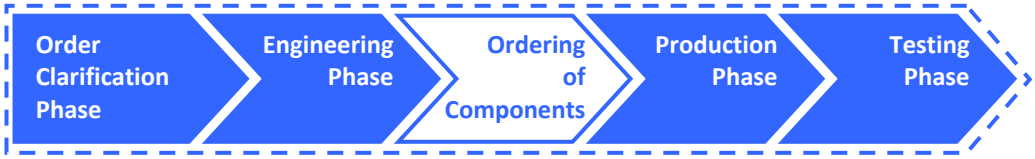
Another minor problem related to this Milestone is that some of the products do not have an automation program, which means that there is neither a planned nor an actual ready date. This is treated by the measuring system as missing information, which lowers the results. The machines that through interviews were identified were the 'TA Drink 1' from Beverage and the 'T Almix 1' from Dairy. In Table 5-14 below is presented how the results would look from January 2008 to January 2009 if these orders were not included in the calculation of the Milestones:

Table 5-14 Automation program, excluding T Almix and TA Drink 1

	All machines		Excluding 'T Almix 1' and 'TA Drink 1'	
	Number of orders	Percentage	Number of orders	Percentage
In time	255	48,9 %*	248	50,5 %
Without information	154	29,6 %	131	26,7 %
Late	112	21,5 %	112	22,8 %
Total	**521**	**100,0 %**	**491**	**100,0 %**
*This percentage differs from the average for unknown reasons.				

In the figure above the reader can observe that the fraction of orders ready in time would be 1.6 % higher without the mentioned orders included. That the fraction of orders without information has decreased should come as no surprise, but that the number of orders ready in time would decrease by seven orders has to be explained further. This phenomenon occurs because the collector of the information in some cases has added "NA" (not available) to both the planned date cell and the ready date cell in the measurement system. Since the information entered for planned and the ready date are the same ("NA"), the measurement system interprets this as if they were the same dates and thus consider these orders as done in time.

Ordering of equipment



Material, Confirmed date & Material, Requested date

The 'Materials, Confirmed date Milestone' does not measure what was intended when it was designed. Comparing the confirmed dates with the actual delivery dates gives a measure on the suppliers' ability to keep their promised delivery day, but unfortunately there is no guarantee that the confirmed date is in line with the contracts. Since the confirmed date is not guaranteed to be based on the delivery time expressed in the contract it could be set to either an earlier or a later date, which means that the measurement results could be good while the process suffers. Two orders taken from December 2008 illustrating the problem is presented in Table 5-15 below.

Table 5-15 Orders late, not caught by the measurement system

Ordered Date	Requested date	Confirmed date	Goods received date	Days between Req. Date and Ord. Date	Days between Conf. Date and Ord. Date	Delivery time according to contract*
2008-12-04	2009-01-16	2009-01-21	2009-01-21	33	36	14
2008-12-10	2009-01-07	2009-01-14	2009-01-13	22	27	19

*The delivery time is including the required time to transport the components from the suppliers to BU DBF's workshop.

For these two orders, the days between the requested date and the ordered date were 33 and 22 days respectively, which is much longer than the delivery time stated in the contract with the supplier, which were 14 and 19 respectively. If these components were needed by the requested date, the process will be affected and the measurement system still gives good results.

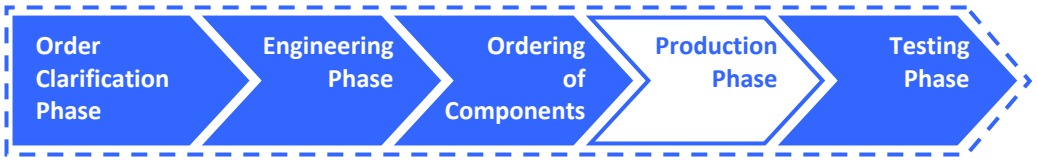
The 'Material, Requested date Milestone' has the purpose to determine the percentage of orders that are delivered before the requested date, in the cases where the difference between order date and requested date is less than the agreed delivery time in the contract.

At the moment though, this measure is taking into account all orders that have a requested date, which in R/3 are *all orders*. This can clearly be seen in Table 5-16 below where every single month the "requested" orders outnumber the confirmed orders.

Table 5-16 Number of orders 'Confirmed delivery date' and 'Requested delivery date'

	Sept 2008	Oct 2008	Nov 2008	Dec 2008	Jan 2009	Feb 2009
Conf. delivery dates	1406	1698	1269	946	830	616
Req. delivery dates	1533	1779	1318	1178	932	885

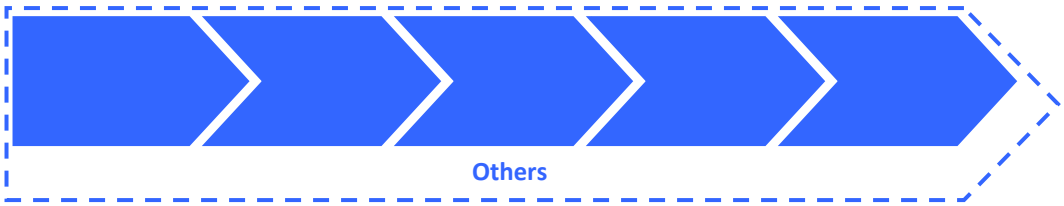
Production phase



Report of rework

Until recently there has for each of the activities in the workshop only been reported one ready date for each production order. This means that for all the activities where rework is needed this activity will be reported as late even if it was done according to the time schedule. This makes it hard to separate issues related to delays in earlier stages and those related to mistakes discovered in for example test. The procedures have been changed earlier this year, so that rework is reported separately.

Others



Misleading name

The 'Fulfilment of Customer request Milestone' measures whether the planned ready date matches the date that has been requested by the MC. Since the Milestone does not consider the actual delivery date, the name is misleading.

Using two different days

The 'Delivery accuracy' not only differs from the 'Delivery_accuracy-R/3' in the aspect that it allows a review on the reasons for a delay. 'Delivery_accuracy-R/3' is further based on a comparison between the 'ActDispDt' with and the 'PlnDispDt' (see definition above) while 'Delivery accuracy' is comparing 'ERDAT' with 'PlnDispDt'. Both 'ERDAT' and 'ActDispDt' are supposed to represent the date when the machine was packed and ready. There are plans to start using 'ERDAT' for retrieving both Milestones. The difference between the two has a significant effect on the results, which can be seen in Table 5-17.

Table 5-17 Comparing ERDAT and 'ActDispDt'

	ERDAT and 'PlnDispDt'		'ActDispDt' and 'PlnDispDt'	
	No. of orders	Percentage	No. of orders	Percentage
On time	276	53%	172	33%
Late	244	47%	351	67%

5.2.2 Measuring

When the measures have been properly determined and designed it is important that the actual measuring is accurate. On a number of points the 'New Milestones' fail to achieve this.

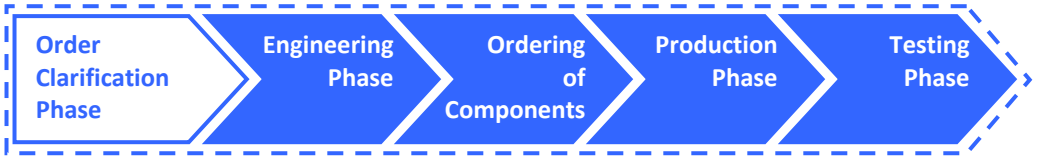
Missing data

For the Milestones obtained manually there exists an extensive problem with data missing. When data is missing for an order it has the same effect on the measurements as of the order was late. This might be valid from a technical measuring point of view, but when the interest is in the process performance this constitutes a problem. In Table 5-18 below the percentage of reported data available is presented for the Milestones obtained manually:

Table 5-18 Data available January 2008 – January 2009

Milestone	Data available
Confirmation of order received	17,3%
Order confirmation	78,5%
BoM ready	85,4%
Mechanical design	94,8%
Input to documentation	76,2%
Automation	70,6%
Average	70,5%

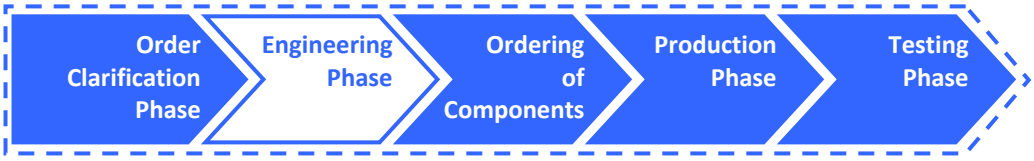
Order clarification phase



Comparing dates instead of counting working days

The 'Confirmation of order received' and 'Order confirmation' milestones both relates the date when the order was received with the actual reported date for sending the confirmation. The definition states that the documents should be sent within three and ten working days respectively, but the measuring compares the difference between dates. In the worst possible case this means that for 'Order confirmation' four days (two weekends) are cut from the available time. For 'Order confirmation' a recalculation of the measured values gives that the average value nearly doubles from 17.9 % to 35 % for the weighted average. For the 'Confirmation of order received' the increase is not as drastic but the weighted average still increases with 1.7 %.

Engineering phase



Incorrect reporting procedures

In the interviews with employees involved in this phase indications were given that some of the manual dates reported might be faulty. This is primarily related to insufficient information on what the dates are used for. In the Revision and approval list for example, the dates entered manually for certain activities should indicate the date of completion for that activity. Some employees that fill in several dates at the same time (at a later date) might fill in the date of reporting, meaning some activities are reported late. This could affect the 'New Milestones'. Take 'T Almix 1' as an example. It is, considered a simple module as it contains a smaller amount of components than the average machine and it further does not require any dimensioning of valves or pumps. Looking at the results of the 'BoM ready Milestone' for this machine from January 2008 to January 2009 Table 5-19 can be constructed:

Table 5-19 BoM Ready for T Almix 1, January 2008 – January 2009

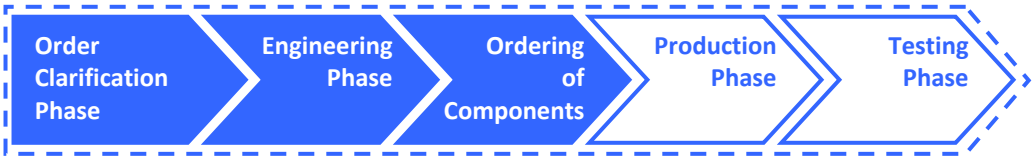
	On time	Without info	Late	Total	Percentage in time
BoM ready	3	2	17	22	13,6%

The results are, based on the description above, the opposite of what can be expected. A closer study of this matter gave that the reported date for all the documents done by the PR in most cases were the same.

Repeated orders

For the 'Documentation Milestone' and the 'Documentation, new machines only Milestone', orders are sometimes repeated in two succeeding months. The reason behind this has not been determined.

Production and testing phase



Non-comparable data

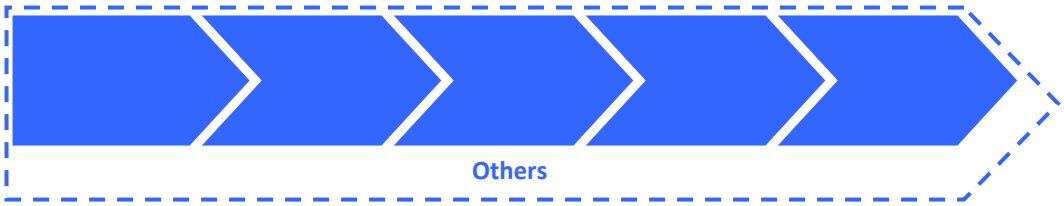
The Milestones reported manually focuses on sales orders related to new products delivered during the relevant month. The Milestones in production on the other hand are focusing on production orders. Further the Milestones for 'Assembly', 'Welding', 'Wiring', 'Testing' and 'Packing' as well as for 'Delivery accuracy R/3', 'Fulfilment of customer request' and 'Orders with dates entered' are taking into consideration orders of upgrades.

This is at the moment not done for Milestones that are calculated manually. From January 2008 to January 2009 that there were are at least 14.2 % more orders in 'Packing', 'Delivery accuracy R/3', 'Fulfilment of customer request' and 'Orders with dates entered' than in the Milestones obtained manually.

Ready date not reported on time
A similar problem exists when for some data collected from R/3 (Welding, Assembly, Wiring, Packing and Testing and Delivery Accuracy R/3 Milestones). The actual finishing dates are compared with the planned finishing dates. Since the workshop operators are not always reporting/closing an activity the same day as they finish it and R/3 does not allow reporting of old dates the measuring system has a built in way of compensating for this. The worst case in delayed reporting involves a weekend and thus three days are added to the planned completion date.

Orders are being repeated in different months
A problem found going through the data is that some orders are measured two or more times for the same Milestone and thereby affecting its final result. One of the worst cases is a sales order that appears two times in the delivery accuracy for the month of March 2008 and two more times for the month of April 2008.

Others



Reporting orders from another production plant – Cold plant
In the process of going through the data it was determined that the Milestones of 'Packing' and 'Delivery accuracy R/3' are also measuring orders from another production plant called 'Cold plant'.

The total numbers of orders that belong to Cold plant were around 110 between January 2008 and January 2009. If the total number of Cold plant orders is divided with the number of orders used in the calculation of the manually obtained Milestones, 520, they constitute 21.2 %. This indicates that these two Milestones are considering at least 21.2 % more orders than the rest of the Milestones.

5.2.3 Summary

The measuring system suffers from problems related both to the design of the measures and the actual measuring. Both of these two types of issues are occurring for almost all of the Milestones, both manual and automatically obtained. An analysis of the problems will be presented in the next chapter, and more detailed recommendations are presented in Appendix J.

6 ANALYSIS

This chapter presents the analysis of the previously presented empirical data. First the focus is on the issues related to the OFCE-process and second on the New Milestones. When possible cause-effect relationships are presented together with recommendations on how the existing system could be improved.

6.1 General assessment of the OFCE-process

In order to better be able to set the presented improvement areas into a proper context a general analysis based on Hammers PEMM model will be presented. The thought behind this analysis is to present the authors view of the process orientation, as opposed to the view of managers and employees of BU DBF.

6.1.1 The PEMM framework

The PEMM (Process Enterprise Maturity Model) framework was developed by the process guru Michael Hammer with the purpose to help managers evaluate how far they have come in the process orientation of their company. The model focuses on two main areas, the processes and the enterprise in which they exist, which in turn are broken down into enablers and capabilities respectively (see Table 3-4 and Appendix A and B).

The framework rates each *process enabler* and *enterprise capability*, on a couple of components, according to a four level scale. For each component and level, the manager using the framework must determine whether the statements are largely true (80 % or more correct), somewhat true (between 20 and 80 % correct) or largely untrue (below 20 % correct). In the evaluations below, largely true is marked with green and 'T', somewhat true is marked with yellow and 'S' and largely untrue is marked with red and 'U'.

6.1.2 PEMM - Processes

Below is presented the filled out version of the Process-PEMM (see Appendix A), followed by comments for each main area (see Figure 6-1).

		P-1	P-2	P-3	P-4
Design	Purpose	T	T	S	S
	Context	T	S	S	S
	Documentation	T	T	S	S
Performers	Knowledge	S	S	U	U
	Skills	S	S	U	U
	Behaviour	T	T	S	S
Owner	Identity	T	T	T	T
	Activities	T	T	S	S
	Authority	T	T	S	S
Infrastructure	Information systems	T	T	S	S
	Human resource systems	T	T	S	U
Metrics	Definition	T	S	S	U
	Uses	T	S	S	U

Figure 6-1 PEMM-evaluation, Processes

Design

The process design has in general progressed far. In the past the company has been even further process oriented, but chosen to take a step back in order to adjust to their way of working. The ERP-system (R/3) has been fitted to support the process, but some work is

still handled outside of R/3 and in some cases the system actually complicates the procedures. The documentation is based on the transactional model and is complete and easy to follow. What still could be improved in terms of design is mostly related to the interfaces with customers and suppliers and the transparency of customer needs. Customer focus is important within Tetra Pak, but most of the employees work far from the customer.

Performers
The knowledge of the performers varies and could be improved especially when it comes to what drives cost and how their work relates to others in the process. Since most of the process change work is initiated by managers and not by the employees, the skills in problem solving and improvement techniques could be improved. Besides the managers the skills in business decision making and change management is limited. Employees to a great extent follow the process directives but could become better in understanding the customer needs and improvements possibilities. The role of each employee is well defined along with responsibilities and authorities. What could improve a lot is the teamwork based thinking, which according to Hammer should be the norm in a process oriented company.

Owner
The Owner of the process is the Operations Director, which main responsibility is the process and its performance. He can in most cases influence and control different systems and budgets, as well as the design of the actual process. The interactions with other external processes (suppliers, customers) could still be improved. Since the first hand customer of BU DBF is the MC and many of the suppliers are other companies within Tetra Pak, better collaboration is something that definitely could be achieved.

Infrastructure
The infrastructure largely supports the process, but has its limits primarily in the communication with external actors. The recruiting of personnel is primarily based on competence rather than special abilities to work in processes. Tetra Pak has a strong culture that both gains and hinders the work with process orientation. Considering the size of the company the infrastructure and systems are surprisingly up to date.

Metrics
The New Milestones is complemented by a lot of different KPIs, but is the only measurement system taking into consideration the whole process on a non-aggregated level. Yet again the development areas lie in the relationships with customer and suppliers. Rationality and measuring are important concepts in all improvement work conducted in BU DBF. All important areas within the process have specific measures that reflect their performance. Improvement possibilities lie within the use of the metrics for benchmarking and improvements as well as for awareness and motivation among employees.

6.1.3 PEMM - Enterprise

Even if the focus of the thesis primarily is on the OFCE process, it is unavoidable to touch upon the Enterprise-PEMM as well (see Appendix B). With 'Enterprise' the authors have chosen to view Tetra Pak and BU DBF interchangeably. Grey squares with 'N' indicate that sufficient information was not available to make a fair assessment (see Figure 6-2).

		E-1	E-2	E-3	E-4
Leadership	Awareness	T	T	T	T
	Alignment	T	T	T	S
	Behaviour	T	T	N	N
	Style	S	T	T	S
Culture	Teamwork	T	S	S	U
	Customer Focus	T	S	S	S
	Responsibility	T	S	S	S
	Attitude towards change	T	S	U	U
Expertise	People	T	T	S	U
	Methodology	T	T	S	U
Governance	Process Model	T	T	S	U
	Accountability	T	T	N	N
	Integration	T	N	S	N

Figure 6-2 PEMM-evaluation, Enterprise

Leadership
The process awareness among senior management is high and relevant training has been provided. Tetra Pak further believes in long term development and improvements which supports this way of thinking. To a large extent process work is handed down to the process owners and the management style is collaborative.

Culture
As mentioned before the way of working team based with improvements is used but could not be considered as a norm. Customer needs are not apparent to all people working in the process, and is largely based on what is ordered (order specifications). Responsibilities for results lie with the managers, while employees are given responsibility of their own work. Change is something that is undergoing but often with little involvement of the employees which can create some resistance.

Expertise
Even though managers have high skills in working with processes, the possession of these skills outside this group are limited.

Governance
The processes are identified within the company and communicated to all employees. The identification of the processes outside of the company on the other hand is limited.

6.2 *Improvement areas within the process*

Despite the rather strong process orientation indicated by the analysis above there exist improvement possibilities in the process. The improvement areas identified in Chapter 5 can be connected to all the process enablers, and in this chapter these findings will be discussed in more detail. Many of the suggestions are connected to improving the results of the Milestones and thus the design of these should be considered simultaneously (see 6.3).

6.2.1 Process evaluation matrices

In order to clearly identify the issues and the most capable person for dealing with them the authors have put together a framework for categorizing the different issues. All of the issues mentioned in the framework will be touched upon in the following subchapters and the framework should thus be seen as an introduction.

Three levels are chosen; strategic, tactical and operational level. If a problem is categorized as strategic it does not mean that this should be handled solely by upper management. Quite on the contrary, it is of vital importance to first determine what knowledge is needed and involve people possessing this knowledge. What the categorization implies is that the responsibility to drive and survey the improvement work should be with the people according to the organizational hierarchy (see Table 6-1).

Table 6-1 Hierarchical levels for process analysis

Strategic level	Long term planning and effects, focusing on the process design
Tactical level	Medium term, month to month basis, focus on individual orders
Operational level	Activity by activity, order by order

The authors have further chosen to divide the matters into three groups depending in what way they affect the process. The three groups are further defined in Table 6-2 below:

Table 6-2 Groups of process analysis

Process agility	Process capability	Process capacity
How flexible is the process when it comes to handling disturbances and unforeseen events? In a longer perspective, how is the process adjusted to changes in customer needs, i.e. its robustness over time.	How well does the process fit with the demands of the different stakeholders, the customer, supplier etc? How is work within the process supported by different systems?	How many orders can be handled simultaneously and how high is the efficiency/effectiveness of the process? Are there any identified bottlenecks?

Combining these two ways of categorizing the process a matrix model can be created in which the different problems/improvement areas can be sorted (see Table 6-3).

Table 6-3 Process Issue Categorization Matrix

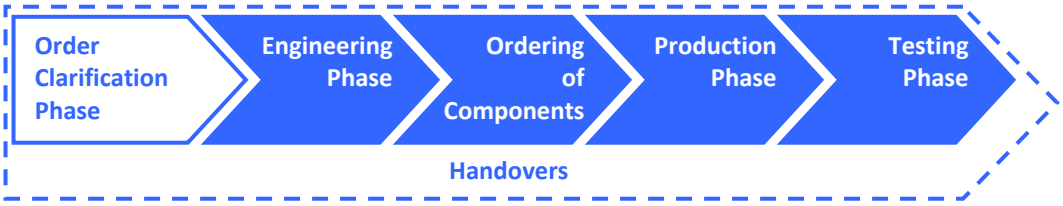
	Process agility	Process capability	Process capacity
Mean of competition	**Fulfil the customer's requests**	**Provide a high quality associated with the Tetra Pak brand**	**Have a delivery time comparable with local competitors**
Strategic Level	▪ Too much customization allowed	▪ Templates for test and mech. design not updated ▪ Accuracy of Perform-acne Measurements ▪ Non-value adding handovers ▪ Not sufficient process awareness among employees	▪ Bottleneck(s) in the workshop ▪ Significant difference in planned and used time ▪ Badly performing suppliers
Tactical Level	▪ Long clarification phase ▪ Insufficient handling of changes ▪ Inferior order forms and MC competence	▪ Lacking feedback on issues of the clarification and engineering phase of the process ▪ Collected feedback is not used in a structured way	▪ Production planning is not handling changes
Operational Level	▪ Process not followed in clarification phase	▪ Low awareness of the New Milestone ▪ Low data availability for manual Milestones	▪ Material not purchased according to contract ▪ Too much rework

The issues identified in the matrix above will be treated further in the following subchapters. To increase the comprehensiveness of the analysis the 'Action Matrix' will be used to catch the suggested improvement actions (see Table 6-4). All the actions are categorized on the same levels as in the matrix above, and further on how hard they are to implement.

Table 6-4 The Action Matrix

	Quick fix	Medium	Hard work
Strategic Level			
Tactical Level			
Operational Level			

6.2.2 Order clarification phase



The performance of the order clarification phase has a great impact on all the succeeding phases. Two factors can be identified as the source of issues; deviations from the process directives and inferior competence and templates.

Deviations from the process directives
The problem with the deviation from directives can be broken down into several pieces.

Differences in the work of the sales managers
To be able to determine how well the clarification phase is working it is important that the process directives and designs are followed. The fact that the SSMs work in different ways complicates the search for issues and only after this variation has been eliminated further analysis could be performed. If the process then is proved to be inefficient, a redesign could be considered.

Urgency in handling of questions
In order to ensure a short clarification phase, it is important to make it clear to the MC that all the time lost in the clarification phase is going to be added to the delivery date. This way there will be pressure put on the MC to take an active part to clarify the order in the shortest possible time. The urgency with which the order clarification is handled depends extensively on the SSM. Some of them are pushing the clarification back at the MC themselves while others leave this to the ORO. Scenario 1 in 5.1.2 illustrates this problem. To have e.g. the ORO driving the clarification phase has both its positive and negative sides (see Table 6-5).

Table 6-5 Positive and negative sides with ORO driving clarification phase

Positive	Negative
+ The ORO follows the order from start to finish in the OFCE process and is thereby more eager to get it off to a good start. + The ORO, having not being part in the reasoning up till the receiving of the order, may have less reservations against informing the MC that every additional day spent in clarification will be added to the delivery date. + One handover would be eliminated and thus the possibility of errors in the transferring of the information to the MC would be reduced.	– The ORO has not the same experience interacting with the employees at the MC and has not been involved with the order up until the point the order is received. – The ORO's in most cases work with multiple orders and have several tasks to handle. Giving them responsibility for the clarification phase would add to their workload.

No matter who handles the clarification, he or she must consider what could be done to minimize the time spent in this phase. One way to simplify the work for the MC is to make sure that the questions (in need of clarifying) are comprehensively formulated and whenever possible, accompanied by recommendations.

Freeze time during clarification
When an order is unclear the SSM should inform the MC that it is not possible to start the work on the order until the questions have been answered. The indication given by the low hit rate of the 'Order confirmation Milestone' is that this is rarely done. One example of this can be seen in Scenario 2 in 5.1.2. Two actions can easily be taken to improve the situation. The first action would be to make sure that the proper forms are used when sending the 'Confirmation of order received'. In the form *'DBF MS 126 - Confirmation of order received, unclear'* is stated:

> "The delivery time stated on Orbis includes 2-3 days for clarification. If more time is needed due to incomplete order data, changes or special requests as well as excess time waiting for clarification data, this time will be added to the date of order confirmation and dispatch date."

The second action would be to use the date when the order was *fully clear* in the order confirmation and base the delivery date on this.

Inferior templates and competence
When it comes to the orders being unclear the problem should be seen from two different angles, the one of the MC and the one of BU DBF.

Market Company's point of view
From the MCs point of view the order form can be incorrectly filled out because of difficulties interpreting in the form or because of lacking information from the end customer.

The responsibility to deal with the former lie with BU DBF, but the information regarding these problems must be caught in some way. Frequent problems should be noted and the responsible person should be informed. Observations made by the authors are that some of these problems are discussed at clarification meetings, but that they are not collected in any structured way. An idea would be to have a list similar to the Correction List Data or the tagging system, to catch and categorize these issues. Another problem related to the order forms is the 'free text fields' in which special requirements are to be put. These appear to be necessary to catch information on customization, but increase the risk of ambiguities. Unless they are absolutely necessary the free text fields should be eliminated.

The problem with missing information from the customer must be solved by the MC with support from the SSM. It is important to be clear with the MC that an order should not be placed until all the information needed has been obtained.

BU DBF's point of view

From a BU DBF point of view the problem is related to the lack of competence at the MCs. When multiple exclusive options are chosen or important information is left out, the order fulfilment cannot be commenced. These types of issues must be solved by offering the proper education. Since educating all people at the MCs would be expensive, a good idea is to first focus on high volume products and markets. In Table 6-6 below MCs are ordered based on their order frequency. The second column presents the percentage of late OC. for how many of the orders the order confirmation was not sent on time.

Table 6-6 Late 'Order confirmations' related to the MCs with more than 10 orders

Market Company	Total number of orders	% late OC
CJSC Tetra Pak	60	51,7%
Tetra Pak Service SA	47	46,8%
Tetra Pak Ltda	42	50,0%
Tetra Pak Makina Ticaret ve	34	52,9%
Tetra Pak China Ltd	22	45,5%
Tetra Pak Hispania S.A.	19	31,6%
Tetra Pak Belgium NV	17	47,1%
Tetra Pak Processing GmbH	16	25,0%
Tetra Pak C.A.	15	53,3%
Tetra Pak Sp. z.o.o.	15	33,3%
Tetra Pak Export (Egypt)	13	53,8%
Tetra Pak Export for Saudi	12	25,0%
Tetra Pak Services (Thai) Ltd	12	16,7%
Tetra Pak Romania SRL	11	36,4%
Tetra Pak Ltd	11	27,3%

From Table 6-6 it is alarming to see that around 50 % of the orders from the biggest MCs have a clarification period long enough to delay the sending of the order confirmation.

Table 6-7 Average number of days between order receiving and sending of the OC

Market Company	No. of late OC	Days between OR and OC (average)
Tetra Pak Belgium NV	8	98
Tetra Pak Processing GmbH	4	38
Tetra Pak China Ltd	10	32
Tetra Pak Services (Thai) Ltd	2	32
Tetra Pak Sp. z.o.o.	5	29
Tetra Pak C.A.	8	27
Tetra Pak Romania SRL	4	27
Tetra Pak Ltda	21	25
CJSC Tetra Pak	31	24
Tetra Pak Makina Ticaret ve	18	24
Tetra Pak Export (Egypt)	7	23
Tetra Pak Ltd	3	22
Tetra Pak Hispania S.A.	6	21
Tetra Pak Service SA	22	19
Tetra Pak Export for Saudi	3	16

Table 6-7 shows that the average time between OR and OC for these orders are between 16 and 98 days, where the process target is 10 days.

These figures only serves as a general illustration of the problem and further inquiries need to be made. Based on the nature of the reasons behind the figures BU DBF/Tetra Pak should develop some kind of educational strategy. If the mistakes made filling out the order forms were caught in a feedback system (e.g. an Excel-file) relating them to the MCs, recurrences could be detected and dealt with more aggressively. Even if the Price book is unclear no MC should make the same mistake twice. The responsibility of administering this file could be given to the ORO, while the identification of mistakes/issues is the common responsibility of the order team during the clarification phase.

Since both the MC and BU DBF exist within the Tetra Pak Group, internal transactions and costs do not affect the result on the bottom line. The *commercial risks* are taken in the interface between the MC and the customer and the importance of having the right competence can be related to two kinds or costs. The first kind of cost arises when a product is sold that deviates a lot from standard and thus making it hard to calculate an accurate price/cost. The second kind of cost is related to selling a product that cannot be produced. The MC then has to return to the customer with this message, and that will most certainly lower the customer's confidence in Tetra Pak.

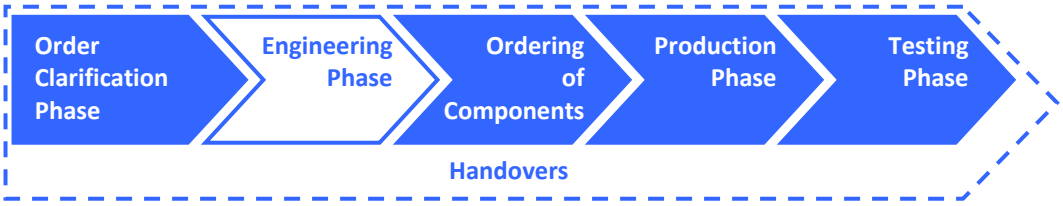
Improvement of the orders forms

Something that could help to reduce the time lost during clarification is having a more complete order form. BU DBF is currently developing a software called Matrix which eventually is going to replace the old order forms. The new software assists the customer when filling out the order form, e.g. by providing additional information for different options and eliminates the possibility to select two mutually exclusive options. Matrix will also be able to create statistical analyses. The recommended actions related to the Order clarification phase are presented in Table 6-8.

Table 6-8 The Action matrix: Order clarification phase

	Quick fix	Medium	Hard work
Strategic Level		▪ Start using collected feedback in a structured way	
Tactical Level	▪ Standardize proce-dures in the handling of order clarification	▪ Collect feedback on issues in clarification phase	▪ Improve order forms/ MC competence
Operational Level	▪ Start following the process directives in the order clarification phase ▪ Formulate recommendations		

6.2.3 Engineering phase



Since most of the orders are customized and the fact that the engineering phase is the phase where most of the variations are introduced it constitutes the biggest challenge when trying to find patterns and improvement possibilities.

Workload and changes

The process demands two things of the engineering phase, that works is completed in the *shortest possible time* and that it at the same time is *correct*. The combination of demands creates an environment where mistakes easily can occur, which results in a need to make changes. The biggest issue with changes is the communication of them. When someone discovers a mistake, or when a request is made by the customer this new information must be passed through to all people involved in the order.

If a mistake is found in the calculations that affect the mechanical design, this is not only an issue between the PR and PD. This will most likely affect AR as well. If the changes cannot be squeezed into the decided time schedule, it will also affect the planning for production and test. If any components need to be substituted then new orders need to be placed and old ones, if possible, need to be cancelled.

To make sure to handle all this in a proper way, there exists a set of activities in the process called 'variation order'. The problem appears to be that this is not always used when it is supposed to be. This could perhaps come down to the fact that the procedure indicates that someone did something wrong and it could mean that an extended delivery time must be requested from the customer. Instead of the variation order one tries to fix it within the time frame and from this the communication problem arises.

As part of the work in becoming lean a challenge is to introduce variation orders as the natural way of dealing with *mistakes (defects)*, and recognize them for what they are, opportunities to learn and improve. If problems are handled in ad hoc ways, then there is a great risk that this information is not turned into knowledge. A way to ensure this would be to introduce a system similar to the Correction List Data.

The M1/M2/M3 project is also likely to reduce the number of faults made, and decrease the lead time. With standardized modules, templates can be adjusted and work routines can be more standardized. The question is whether this will increase the eighth waste, *unexploited creativity*.

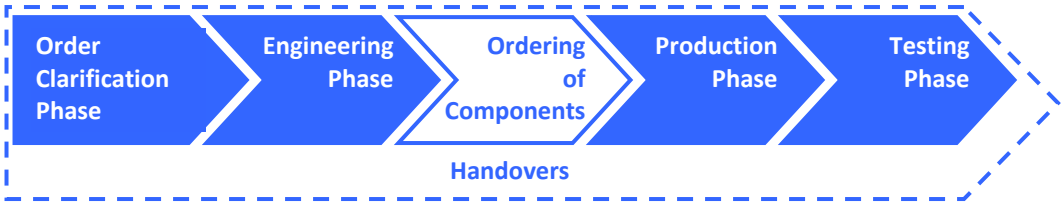
Planning support and visibility through R/3

The way the engineering phase is planned puts a lot of responsibility on the PR and AR. They plan their own work, and have to deal with a lot of different tasks at the same time. The only reporting they do is done manually in the Revision and approval list. If the work with an order was broken down into major components that could be reported in R/3, this could serve two purposes. Partly it could be a way to ensure a more accurate measuring of how work was progressing (Milestones) and partly it could act as a help in the planning and prioritizing of the work. If used correctly it could also be used to increase visibility of how the orders progress in earlier stages of the process. In general feedback from this phase is lacking which makes it hard to identify key improvement areas and the root causes of the problems. *Activity based reporting* in R/3 would be an essential part of this. The recommended actions related to the Engineering phase are presented in Table 6-9.

Table 6-9 The Action matrix: Engineering phase

	Quick fix	Medium	Hard work
Strategic Level			▪ M1/M2/M3
Tactical Level		▪ Collect feedback on issues in engineering phase ▪ Employ a more structured handling of changes	
Operational Level		▪ Start using the variation order procedure when needed	

6.2.4 Ordering of components



The two main improvement areas in the ordering of components are related to the inter-organizational cooperation. In order to solve or at least limit the problems there needs to be a better dialogue focusing on mutual understanding.

Issues with purchasing

When working with a centralized purchasing organization and agreements that are not rapidly changed it is of course important to follow the rules that the agreements state. As previously seen in 5.1.4 the problems with delays do not seem to be connected to one side of the interface. The fact that the average share of components that were requested earlier than the agreement for the largest eleven suppliers was 41 % is alarming, especially

considering that only around 60 % of the orders are delivered at the requested date. Since these suppliers provide BU DBF with almost half of its ordered components, this issues should be further investigated. Assuming that the contracts are up to date there are strong reasons to believe that the issues are connected to earlier stages of the process. If everything had moved along as intended for the preceding activities, it would not be necessary to request a shorter delivery time than agreed in the contract for any of the components. Most likely the reasons behind the bad figures are long clarification phases (where time was not frozen) or problems with the technical specification of the order.

Today, there seems to exist a false sense of safety that the suppliers can satisfy almost every request. This might be true in some cases, but if the ambition to become lean and achieve the lions benefits of WCM this attitude must be changed. There is not any greater meaning in putting pressure on the suppliers until the internal work is conducted in a satisfying way. In the same way that you cannot expect the assembly line to be ready in five days time if their components are delivered late, you cannot expect the suppliers to deliver an order in time unless they receive the order when agreed.

Issues with deliveries

The problems with the external deliveries are partly related to confirmations of later dates than what is stated in the contract and partly to late deliveries. Both of these ultimately causes a need to re-plan and thus are unacceptable in a lean organization. In the relation with the suppliers, there are at least four ways to deal with the issue that can be initiated by BU DBF (see
Table 6-10).

Table 6-10 Four ways of dealing with supplier issues

Four ways to deal with supplier issues
▪ Set up *fines* for late deliveries. If the delay induces costs for Tetra Pak, why should the supplier not pay for these? This arrangement has been used by Volvo in the relation to their sub-suppliers, as a mean to ensure JIT deliveries. This of course presumes that the order flow from Tetra Pak constitute a large enough proportion of the suppliers intake, otherwise the supplier might not accept such agreements. ▪ In the case where changing the supplier is not a desirable/feasible alternative, a more "positive pressure" could be put on the suppliers involved, e.g. through *incentives* for deliveries on time. How and on what grounds these incentives should be based must be related to calculations of the alternative costs. ▪ Invite to discussions around each of the companies processes and ways of working. If the relationship is long term this should be a natural step towards process integration, and could result in changes in routines that could save time in both ends. The thoughts presented in section 3.2.4 sees this as a succeeding step to achieving internal process excellence, but the authors view is that this work cannot start soon enough. ▪ If none of the above suggestions are applicable, the supplier should be exchanged. If the supplier is considered important this is of course something that should be avoided if possible, but there is no rational motivation to keep a supplier that deteriorates the process performance.

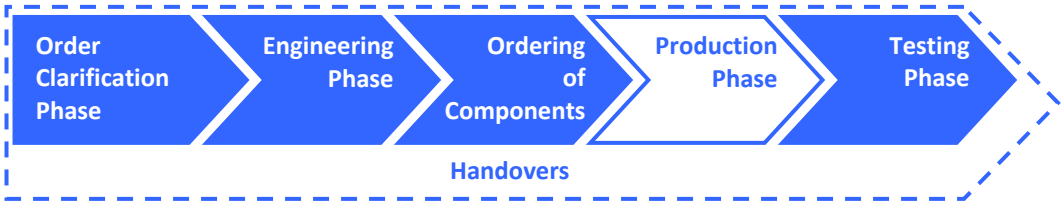
An interesting observation worth mentioning is that the empirical data confirms the statements that Alfa Laval Kolding (LKM), the supplier with the highest volume, is not delivering according to agreements. On the other hand, they also point out that as many as 50 % of the orders to Alfa Laval Kolding, have a requested delivery time shorter than agreed. Neither of this should be accepted.

Many of the eleven suppliers studied in this report are companies that the owners of Tetra Pak have interests in and an interesting observation is that the intra-company suppliers are neither better nor worse than any of the external ones. This type of relation of course complicates the situation since to substitute them either is not an alternative or in best case is a sensitive matter. The opportunities to discuss internal needs and solutions on the other hand are greater, especially between companies within Tetra Pak. The recommended actions related to the Ordering of components are presented in Table 6-11.

Table 6-11 The Action matrix: Ordering of components

	Quick fix	Medium	Hard work
Strategic Level			▪ Choose suppliers to fit the process needs ▪ Establish dialogue and introduce incentives or fines
Tactical Level			
Operational Level		▪ Purchase according to terms in contract	

6.2.5 Production phase



The Global Business Expert mentioned that there are as many as 125 different systems used for administering and planning different activities in the process. Since not all of them (or rather very few of them) are integrated there are good reasons to believe that it will cause problems.

Planning

Planning of production is one area where some of the problems can be connected to the supporting systems. If the orders were simple and changes were seldom made to them the system appears to be appropriate. The reality is another and the weaknesses of the system shine through. Figure 6-3 illustrates the structure of the current planning system.

To illustrate the issues, let us assume that the welding is late. The responsible for daily planning in welding should then report this to the responsible production planner, who in turn should try to re-plan the order to fit with capacity. If this is possible the planned dates in R/3 should be updated by the CRP. The production planner must also contact the daily planners for each function to inform about the new planning. Since everything in the workshop is done JIT, one faulty drawing, welded component or late component starts the need of re-planning.

Today the re-planning is not done in most cases. This is indicated by the fact that carriers with picked material clutter up the workshop (breaking the rules of the 5S). It also explains why there in the interviews have been mentioned that tests are not re-planned. The wastes that are present here are primarily *transport* and *inappropriate processing*, but to a certain extent also *waiting*.

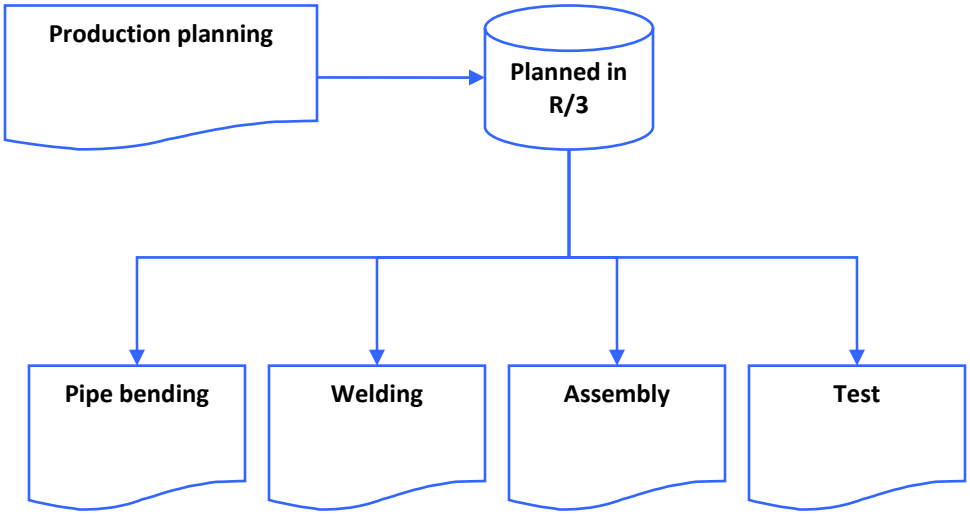


Figure 6-3 Production planning

The only good way to come around this issue is if everybody used the same system or if the procedures for changes are greatly simplified. A recent taken initiative to overcome these problems (or at least limit their impact) is the implementation of a section in R/3 that displays *all the production orders* with their planned start date, planned finished date, the number of assigned hours, the number of assigned hours already used etc. This can be used as a support for the daily planning in production, and makes it possible to in a good way compare the orders in R/3 with the ones on the Excel sheets showing the daily planning in the workshop. This might limit the symptoms but it does not eliminate the root causes.

Another tool that could help out in minimizing the problems related to planning/re-planning is *levelling*. The use of levelling on the other hand still demands a better coordination between the systems to be effective. Without a co-ordination between the levelling done in R/3 and the day-to-day planning in the workshop the initiative is of little use.

Problems and delays
Since the production activities are done in lines, with JIT handovers one issue is enough to cause delays. Based on what is reported in the *tagging system* the problems originate both from earlier stages in the workshop activities and in engineering and design. A delay in the delivery of a component could have the same effect. If one activity is late it is very likely that the succeeding activities also will be late. Considering this situation, the use of *poka-yoke* tools to limit the number of mistakes would be beneficial.

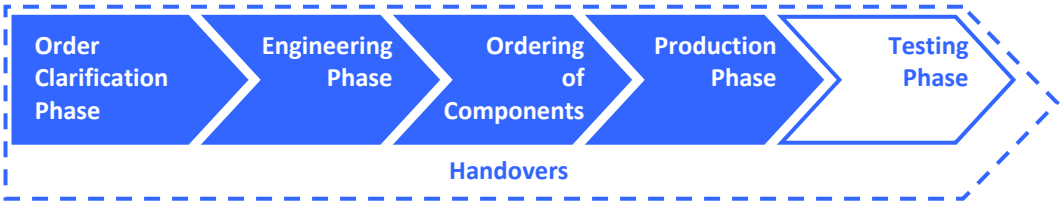
Capacity
Another issue that have been mentioned in interviews is the existence of bottlenecks in production. The assembly lines can handle ten machines simultaneously and to start on two new machines every day. To be able to use capacity to the full, it needs to be provided with the right components and material. One issue is of course the delivery of components from suppliers. The other issue is the delivery of "manufactured" components from pipe bending and welding. Previously pipe bending seemed to be the largest bottleneck, but this seems for the moment at least have been pushed forward to welding. At the moment one welding line is serving two assembly lines.

Exactly how large the issues are is hard to determine without studying this area in detail, but in our interviews a couple of possible reasons have been identified. One reason is that hiring consultants with the right competence is difficult, making it hard to handle temporary increases in order intake. Another reason suggested by internal studies is that efficiency for rework is considerably lower than first time work. Rework is waste and should be avoided in a lean company. To ensure this the poka-yoke concept should be introduced. The last observation is that welders are used to help finish assembly on time, decreasing capacity in welding. The recommended actions related to the Production phase are presented in
Table 6-12.

Table 6-12 The Action matrix: Production phase

	Quick fix	Medium	Hard work
Strategic Level		▪ Evaluate capacity in production (welding)	
Tactical Level		▪ Start using levelling ▪ Establish routines for re-planning	▪ Integrate the production planning systems
Operational Level			▪ Eliminate rework – use Poka-yoke

6.2.6 Testing phase



MCs have on several occasions had remarks on the quality of the delivered product and attention has thus been directed towards testing as a problem area. The findings of this report suggest that this attention to a large extent is unjustified. That there exist problems here in form of lack of experience and competence is acknowledged, but at the same time other parts of the process do not seem to offer the support needed.

From January to Mars 2009, the number of orders that were completed later than planned in assembly according to the daily planning was around 50 %, and when late, they were in average 2.6 days late. This considered together with the fact that in average 11.6 hours, equivalent to almost one and a half working day, are taken from the intended testing time to correct problems, it is understandable that some functional issues are missed when working towards meeting the deadline.

Feedback

Testing essentially has two main functions. The most apparent one is making sure that the product is fault free when delivered to the customer. A problem in this ambition is that the product only can be tested with water and steam and not with the intended product. This means that some issues cannot be detected until the commissioning. The second function is to collect feedback for process improvement. The observations made through studying the Correction List Data is that the feedback collected is not always treated in a systematic way. A lot of the problems are related to mistakes and misunderstandings, which in terms of learning are of most interest to the responsible person. Other issues might be more related to the general design and template problems which should be addressed by the appropriate authority. The TA Drink example presented in 5.1.6 is a typical step in the right direction, but unfortunately this seems to be unique.

When prioritizing between improvement initiatives it is important to first determine which areas would benefit most of this work. As could be observed in 5.1.6 automation is the main source of problems during the testing of the machines. It represents almost 35 % of the time lost in test and it thus seems like a good idea to focus improvement work to this area. A first step is to ensure that the desktop tests are performed.

As all the machines are very different in terms of characteristics and functionalities, the focus should be put on the machines that loses the most time in testing. The three machines that loose the most time in aggregation are TA VTIS 100, TA Flex 10, and TA

Drink 10. A further breakdown of the time lost for these three can be seen in Table 6-13, Table 6-14 and Table 6-15 below.

Table 6-13 Time lost for the machine TA VTIS 100, January 2008 – May 2009

Fault type	Faults identified in test		Time lost due to faults	
	Number of faults	Percentage	Sum of time (hours)	Percentage
Automation	343	53.8 %	337.5	49.3 %
Delays	12	1.9 %	115.5	16.9 %
Process	62	9.7 %	65.8	9.6 %
Mechanical assembly	78	12.2 %	38.0	5.5 %
Component - process	38	6.0 %	36.1	5.3 %
Other	105	16.5 %	92.2	13.5 %
Total	**638**	**100 %**	**685.1**	**100 %**

For the machine TA VTIS 100 the fault that causes the most loss of time is the automation, which amounts to 49.3 % of the total time. For this machine a further investigation of the templates and work routines for automation should be done.

Table 6-14 Time lost for the machine TA Flex 10, January 2008 – May 2009

Fault type	Faults identified in test		Time lost due to faults	
	Number of faults	Percentage	Sum of time (hours)	Percentage
Automation	192	28.9 %	174.9	26.4 %
Mechanical assembly	198	29.8 %	129.6	19.6 %
Electrical installation	131	19.7 %	90.9	13.7 %
Component - process	43	6.5 %	82.5	12.5 %
Delays	10	1.5 %	73.0	11.0 %
Other	91	13.7 %	111.3	16.8 %
Total	**665**	**100 %**	**662.2**	**100 %**

For the TA Flex 10, the two main faults types are automation and mechanical assembly which represent 26.4 % and 19.6 % of the time lost in test. These areas should be analyzed further.

Table 6-15 Time lost for the machine TA Drink 100, January 2008 – May 2009

Fault type	Faults identified in test		Time lost due to faults	
	Number of faults	Percentage	Sum of time (hours)	Percentage
Automation	142	39.9 %	135.3	41.8 %
Mechanical assembly	104	29.2 %	63.6	19.7 %
Delays	6	1.7 %	36.0	11.1 %
Process	30	8.4 %	30.4	9.4 %
Idea	11	3.1 %	20.3	6.3 %
Other	63	17.7 %	37.8	11.7 %
Total	**356**	**100 %**	**323.3**	**100 %**

For TA Drink 100 most of the problems are, once again, related to the automation, which represents 41.8 % of the total time lost.

This type of analysis could be done for all machines, based on some priority order. The more complex products generally lose more time in test than the simpler ones. The M1/M2/M3 project should when implemented result in even less time lost for M1 and M2 machines since tests can be 100 % standardized.

A more structured work with the feedback would most likely have at least three positive effects:

- Better product templates and guidelines
- Better understanding among designers and programmers
- Increased motivation among testers

The problem with this is of course that it demands resources, mostly in terms of peoples' time. To motivate that this still can be worth considering one can look at the additional reported hours in test. The average time lost per machine has during the last four years has been ranging between 6 and 18 hours and with an average on 1.13 hours per fault found.

Competence and support
The competence is a key factor in testing and the best way to build it seems to be through practical experience. Without the proper competence mistakes are made, and to avoid them all is close to impossible. Focus should instead be on what could be done to limit the risk of mistakes.

TR does not always call to a preparatory and a follow up meeting for the test
From the testers' point of view, preparation is very important. The process states that a preparatory meeting should be held with AR and PR. This is a golden opportunity to catch deviations from standard and other important characteristics. As previously mentioned these meetings do not always occur and a deviation from the process is thereby introduced without any apparent reason. The same goes for the follow up meetings which in their turn can be seen as an opportunity for the AR/PR to learn how their work could be improved. As stated in the empirical part, the trend is that these meeting are occurring in a greater extent, but the percentage for the first five months of 2009 are between 67-75 % which still is a long way from following the process.

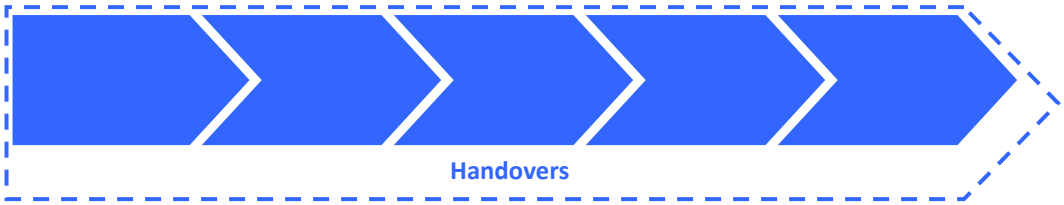
The test guidelines are not up to date
The ASR's/TPM's responsibility is to keep the templates and documents supporting test up to date. That there exist differences in layout between the food categories seems like another unnecessary source of confusion. There exists today no apparent reason to why the layouts should be different.

In summary the increasing of performance of the testers should be considered a joint effort from all the people involved in the process. The recommended actions related to the Testing phase are presented in Table 6-16.

Table 6-16 The Action matrix: Testing phase

	Quick fix	Medium	Hard work
Strategic Level		▪ Start using collected feedback in a structured way ▪ Streamline testing guidelines	▪ M1/M2/M3 ▪ Increase process awareness
Tactical Level	▪ Ensure that the preparatory and follow up meetings to test are held		▪ Integrate the production planning systems
Operational Level	▪ Always perform desktop test		

6.2.7 Handovers



Handovers as such can be seen as wastes in the Lean methodology (*transport*), and thus their occurrence should be minimized. In the context of delays and problems in the OFCE process, the handovers cannot be seen as a major cause but rather as a catalyst of the negative effects. If something needs to be redone or changed which affects people throughout the process, every handover is a risk of delay or diffusion of the information. The person discovering and initiating the change has to rely on that the people they contact in turn will pass the information through to their "customers".

The question of handover ultimately comes down to the definition of roles and areas of responsibility. At present a lot of administrative responsibility is put on the PR, which in some cases perhaps could be avoided. The example with the control panels is the most evident one, where PR only seems to have the administrative responsibility, but the technical responsibility lie with the AR. By using value stream mapping and 5 why techniques when going through phases of the process issues like these can be identified and improvements can be made.

When Hammer talks about the integration of enterprises he mentions that tasks that are otherwise performed twice should only be performed by the company that does it best. The same thoughts should be applied when it comes to handovers. If the involved employees

were given the opportunity and the right tools they could probably identify and agree on a number of activities that could be transferred to other roles. The process owner and managers, together with the Quality and Business experts could then evaluate the suggestions. This could either be done as part of a larger initiative within WCM using VSM as a tool to identify all kind of wastes, or in smaller scale involving a pilot project.

One positive effect from evaluating the roles could be more *natural handovers*. A natural handover implicates that whenever an issue is found (e.g. a suspicious specification in an order for a control panel) then the same person is responsible for both for the specification and the placing of the order (see Figure 6-4).

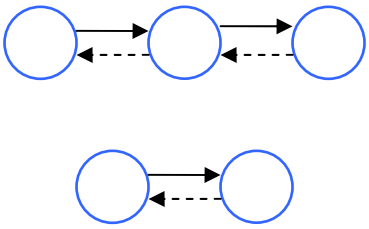


Figure 6-4 One step (natural) and two step handover

The idea of having one responsible for each document (such as the BoM) is of course a way of keeping track of the work being done. The problem with this "one bullet" way of organizing is of course when matters need to be handed quickly and without delays. As long as it is possible to keep track of what has been done by who a common responsibility could instead be seen as a step towards a more teamwork based organization. The recommended actions related to the handovers are presented in Table 6-17.

Table 6-17 The Action matrix: Handovers

	Quick fix	Medium	Hard work
Strategic Level		▪ Evaluate the handovers ▪ Evaluate responsibilities of different roles	
Tactical Level			
Operational Level			

6.2.8 Costs and planned time

The example given in 5.1.1 as an indication on how much the catching up in the process costs on a yearly basis should only be treated as an estimate on the effects of delays. In relation to this the question of how the planned times are calculated should be mentioned. The given time for each activity is on a yearly base reduced with typically 10 %, which should be achieved through increased efficiency and learning.

If a follow up on how well this was achieved is done for three products the results are mixed. Since only monthly accumulated data are available, the difference presented below is between planned and actual for each year. If the difference is increasing (I) then the process work is not able to follow the targets. If the difference is decreasing the (D) then the process is performing better than the previous year. Whenever the difference is above 100 % the number of hours used are larger than the planned (see Table 6-18, Table 6-19 and Table 6-20).

Table 6-18 Difference between planned and actual time TA Drink 10/100

TA Drink 10/100			
Activity	**Difference 2007**	**Difference 2008**	**Development**
Administration	89,8 %	120,3 %	I
Mechanical design	94,9 %	131,0 %	I
Process design	72,2 %	121,5 %	I
Pipe bending	121,3 %	115,4 %	D
Assembly	107,8 %	126,1 %	I
Welding	N/A	118,4 %	N/A
Wiring	117,1 %	148,1 %	I
Test	123,5 %	114,5 %	D

Table 6-19 Difference between planned and actual time TA Flex 10/100

TA Flex 10/100			
Activity	**Difference 2007**	**Difference 2008**	**Development**
Administration	115,2 %	72,6 %	D
Mechanical design	114,7 %	137,2 %	I
Process design	88,5 %	97,1 %	I
Pipe bending	126,8 %	120,3 %	D
Assembly	133,6 %	141,0 %	I
Welding	110,2 %	111,6 %	I
Wiring	109,3 %	137,9 %	I
Test	121,1 %	115,7 %	D

Table 6-20 Difference between planned and actual time TT Lacta 10/100

TT Lacta 10/100			
Activity	**Difference 2007**	**Difference 2008**	**Development**
Administration	99,7 %	77,1 %	D
Mechanical design	137,7 %	101,1 %	D
Process design	105,0 %	90,4 %	D
Pipe bending	125,9 %	115,2 %	D
Assembly	104,2 %	121,3 %	I
Welding	94,6 %	103,0 %	I
Wiring	106,4 %	124,3 %	I
Test	102,6 %	128,2 %	I

The occurrence of increasing differences indicates that the process in general has a hard time keeping up with the requested development. The number of reported hours spent on administration seem to have been a target in Dairy (Flex and Lacta) and are now well below

the planned amount, while the improvements in Assembly, Welding and Wiring seem to be nonexistent.

6.2.9 Summary – the chain of events

In Table 6-21 below the actions from the previous chapters are presented.

Table 6-21 Process Improvement Difficulty Matrix

	Quick fix	Medium	Hard work
Strategic Level		▪ Start using collected feedback in a structured way ▪ Evaluate capacity in production (welding) ▪ Streamline testing guidelines ▪ Evaluate the handovers ▪ Evaluate responsibilities of different roles	▪ M1/M2/M3 ▪ Choose suppliers to fit the process needs ▪ Establish dialogue and introduce incentives or fines ▪ Evaluate the compliance between planned time and needed ▪ Increase process awareness
Tactical Level	▪ Standardize proce-dures in the handling of order clarification ▪ Ensure that the preparatory and follow up meetings to test are held	▪ Collect feedback on issues in clarification and engineering phase ▪ Employ a more structured handling of changes ▪ Start using levelling ▪ Establish routines for re-planning	▪ Integrate the production planning systems ▪ Improve order forms/ MC competence
Operational Level	▪ Start following the process directives in the order clarification phase ▪ Formulate recommendations ▪ Always perform desktop test	▪ Start using the variation order procedure when needed ▪ Purchase according to terms in contract	▪ Eliminate rework – use Poka-yoke

The issues identified in this report all in part explain the problems showing in the Milestones. An important insight though is that a bad result for a specific Milestone most likely is not linked only to the performance of the particular part of the process which it is measuring. This has already been observed by BU DBF, being the reason for expanding the measurement system.

Further there in most cases is not one cause for each problem, but rather several of them. To be able to solve them people with different roles need to be involved, in some cases on a continual basis. In general the present problem can be illustrated by Figure 6-5 below. The intended cycle is that measuring is done on the process to provide feedback. The feedback is analyzed and corrective actions are taken to the process. The measuring is continued and gives feedback on the actions taken.

The problem today is that the feedback provided by the measurements is not enough to be turned into corrective actions. The suggestions presented in the matrix above are thus in large focused on what needs to be investigated further and what kind of feedback should be collected to determine the route causes of the problems.

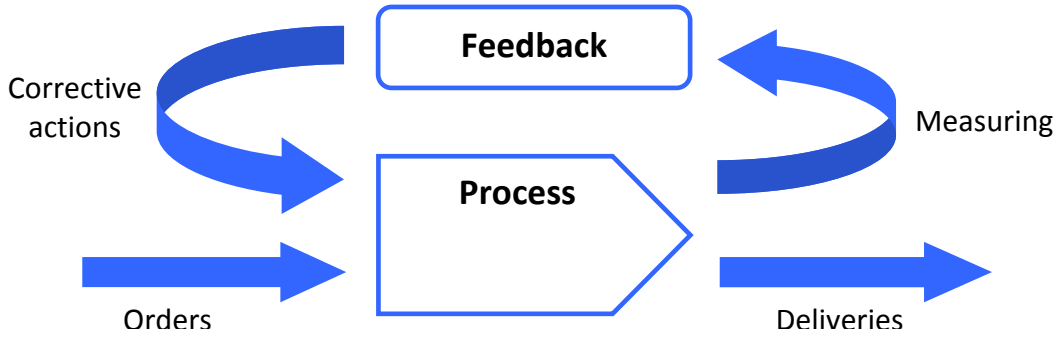


Figure 6-5 Different stages in measuring and improving

6.3 *Improvements of the measuring system*

6.3.1 Evaluation matrix – Recommendations vs. Milestones

In order to do a full evaluation of the measurement system 20 out of the 22 recommendations collected by Bourne et al. (See Table 3-5) have been selected. These are put against the New Milestones to create a matrix. The recommendations are further divided into three groups; 'Definition and purpose', 'Feedback' and 'Improvements'. For each of the recommendation the authors have evaluated whether it is fulfilled for each of the Milestones. Three levels are used; true, indicated by green and 'T', somewhat true, indicated by yellow and 'S' and untrue, indicated by red and 'U'.

6.3.2 Group 1: Definitions and purpose

The evaluation is presented in Figure 6-6 below, followed by comments.

Levels of evaluation T = True S = Somewhat true U = Untrue	1) Be derived from strategy	2) Have an explicit purpose	3) Reflect the business process	4) Be relevant	5) Be clearly defined	6) Relate to specific goals
Confirmation of Order Received	T	T	T	T	T	S
Order Confirmation	T	T	T	T	S	S
BoM ready	T	T	U	T	S	S
Material, Confirmed date	T	T	U	T	S	S
Material, Requested date	T	T	U	T	S	S
Mechanical design	T	T	U	T	T	S
Pipe bending	T	T	U	T	S	S
Welding	T	T	U	T	S	S
Assembly	T	T	U	T	S	S
Wiring	T	T	U	T	S	S
Automation programs	T	T	U	T	S	S
Test	T	T	U	T	S	S
Packing	T	T	U	T	S	S
Fulfilment of Customer Request	T	S	U	S	S	S
Orders with dates entered	T	S	U	U	S	S
Delivery Accuracy - R/3	T	U	U	U	S	U
Input for Documentation compiling	T	T	T	T	T	S
Documentation	T	T	T	T	S	S
Documentation, New machines only	T	T	T	S	S	S
Delivery Accuracy	T	T	U	T	S	T

Figure 6-6 Evaluation of measurement system: Definition and purpose

1) Derived from strategy
The strategy primarily focuses on delivering superior customer value in terms of quality, but internally the focus is set on minimizing the lead time in relation to delivery time. The New Milestones follow orders through the process and is intended to indicate where shortcomings exist. Improving these will lead to a process better capable of delivering the high customer value and it is thus the authors' opinion that the system fulfils this recommendation.

2) Have an explicit purpose
Most of the New Milestones have an explicit purpose as they are measuring important activities in the process in order to determine improvement possibilities. However, the purpose of 'Fulfilment of customer request' is very questionable as it is based on a planned dates instead of the actual delivery date. 'Orders with dates entered Milestone' also seems a redundant as it only indicates the percentage of orders used to calculate 'Fulfilment of customer request'. No other Milestone has an indication of how many orders have dates entered. The purpose of 'Delivery accuracy R/3 Milestone' is also hard to see, since the 'Delivery accuracy Milestone' measures the same part of the process. As a system the New Milestones fulfil the recommendation.

3) Reflect the "business process"
- i.e. both the supplier and customer should be involved in the definition of the measure
The New Milestones is a measurement system that to a great extent is used to measure internal work and not so much the interfaces with external partners. On the other hand, some of the most prominent problems presented in this report are related to these interfaces. On a longer sight the integration of processes can be a key to increase the competitiveness and thus should be reflected in the measurement system. Customers should for example be involved in the design of the delivery accuracy measure. The system in general does at this point not fulfil this recommendation.

4) Be relevant
The New Milestones in a good way meet the recommendation that the measures should be relevant as most of them jointly reflect how the OFCE-process is performing. However, 'Fulfilment of customer request', 'Orders with dates entered' and Delivery accuracy R/3' are not relevant for the same reasons stated above. Further there does not seem to be an apparent reason to separate 'Documentation' (measuring new machines and upgrades) from 'Documentation, New machines only', since the Milestones in the workshop measure these two groups together.

5) Clearly defined
After searching for the specifications on how the Milestones should be calculated, the authors could only find these for the manually collected ones. This renders the yellow marking for all the automated Milestones. 'Order confirmation' is marked yellow since the specification does not indicate how the orders with longer clarification phase should be reported. 'BoM Ready' and 'Automation program' are also marked yellow because the

specification does not indicate how the changes requested by the customer should be handled. In general it would be a good idea to use a tool similar to the 'record sheet' presented in 3.3.3. This would force everyone involved to re-consider what is being measured and why it is being measured.

6) Relate to specific goals (targets)

Most of the New Milestones are marked yellow because the only target set for them is to achieve 100 %. 'Delivery accuracy R/3 Milestone' is marked red since no focus is put on this. The only Milestone with a clear goal is 'Delivery accuracy', which for each month has a target that over 95 % of the orders should be delivered on time. To set up short term goals would most likely be beneficial, since these would represent something that all the people involved should strive to achieve. In general the system does not fulfil this recommendation.

6.3.3 Group 2: Feedback

The evaluation is presented in Figure 6-7 below, followed by comments.

Levels of evaluation
T = True
S = Somewhat true
U = Untrue

	7) Timely and accurate feedback	8) Provide fast feedback	9) Simple consistent format	10) Automatically collected data	11) Employ ratios	12) Be simple to understand	13) Have visual impact	14) Be objective	15) Be consistent
Confirmation of Order Received	U	U	T	U	T	T	S	T	T
Order Confirmation	U	U	T	U	T	T	S	T	T
BoM ready	S	U	T	U	T	T	S	T	T
Material, Confirmed date	U	U	T	T	T	T	S	T	T
Material, Requested date	U	U	T	T	T	T	S	T	T
Mechanical design	T	U	T	U	T	T	T	T	S
Pipe bending	U	S	T	T	T	T	T	T	T
Welding	T	S	T	T	T	T	T	T	T
Assembly	T	S	T	T	T	T	T	T	T
Wiring	T	S	T	T	T	T	T	T	T
Automation programs	S	S	T	U	T	T	S	T	T
Test	T	S	T	T	T	T	T	T	T
Packing	T	S	T	T	T	T	T	T	T
Fulfilment of Customer Request	T	U	T	T	T	U	S	T	T
Orders with dates entered	T	U	T	T	T	U	S	T	T
Delivery Accuracy - R/3	U	U	T	T	T	T	T	T	T
Input for Documentation compiling	T	S	T	U	T	T	S	T	T
Documentation	T	S	T	U	T	T	T	T	T
Documentation, New machines only	T	S	T	U	T	T	T	T	T
Delivery Accuracy	S	T	T	U	T	U	T	S	T

Figure 6-7 Evaluation of measurement system: Feedback

7) Provide timely and accurate feedback

When it comes to providing timely and accurate feedback the system fails on several points, but for different reasons. The first Milestone suffers from lack of available data, the second from incorrect measuring, and the third from a vague definition in how it should be measured. The two Milestones related to material are not measuring what they are intended to measure. The 'Pipe bending Milestone' has for a long period not been measured at all and now suffers from incorrect data handling. The 'Automation program Milestone' has the same problem as the 'BoM ready Milestone'. Delivery accuracy R/3 does not provide any usable feedback, and last but not least the 'Delivery Accuracy Milestone'

comes with a number of conditions that alters the results. The Milestones marked in red are of a more serious nature, than the ones market with yellow. The overall credibility of the system is rather low, which limits the possibility to use the results in an evaluation of the system.

8) Provide fast feedback
The procedure to connect all the data to the machines being delivered a certain month is good since it allows an evaluation of the how the orders were handled on their way through the process. This information could be used in a longer perspective to evaluate the performance and the impact of changes. In a shorter perspective on the other hand, the system does not work very well. Most of the early activities were done several months before the results are presented, which makes it difficult to find information on what went wrong and why. The later activities are usually performed between one and three months before the results are presented. In order to improve a combination of fast and more detailed feedback is needed and thus the system of reporting should be changed or extended (more on this in 6.4.1). The overall evaluation is that the system does not fulfil this recommendation.

9) Be reported in a simple, consistent format
The New Milestones are reported in form of a column diagram once every month. The diagram is both simple and consistent and has only changed when the new measures were added. The system thus fulfils this recommendation.

10) Use data which are automatically collected as part of a process whenever possible
Out of 20 Milestones only 11 are automatically collected, while the remaining 9 include some kind of manual collection or adjustment. Whether a measure should be collected automatically or manually comes down to applicability and flexibility. Manual measuring increases the flexibility, but increases the need for training among the people involved. If there is a low reporting rate or different ways of reporting the credibility of the measurements decreases fast. This is a problem that is occurring in the present system.

The automatic measuring decreases the risk for human faults and deviances but demands that the system supports the intension with the measurements. Today the automated Milestones include information that probably should not be there, and have built in systematic errors. The benefits from automating the measurements still seems greater than the disadvantages and indications have been given that some of the manual measurements that exist today could be automated. The system in general does not fulfil this recommendation.

11) Employ ratios rather than absolute numbers
The system uses ratios when evaluating the performance and thereby fulfils the recommendation. What could be of great use in evaluation of the results is the number of orders delivered each month. One would expect there to be differences between months with 25 and 75 machines handled and delivered.

12) Simple to understand

Whether a measure is simple to understand or not of course comes down to who the receiver of the information is. As for right now the New Milestones are mostly used by managers who all have part taken in the development of the system. The authors have thus stretched the definition of "understanding" to whether or not the measure makes sense to someone who has been introduced to it and exposed to the results. With this definition all the measures are simple to understand, with exception from 'Fulfilment of customer request', 'Orders with dates entered' and 'Delivery Accuracy'. The first two makes little sense in why they are measured, while the calculation of the latter is rather complicated. To make the results more accessible to all employees, a suggestion is that all Milestones should be accompanied by proper descriptions. The record sheet presented in 3.3.3 could be a mean to achieve this. In general the system fulfils this recommendation.

13) Have visual impact

The visual impact of the Milestones and many other measurements are in general good. In the workshop, in the mechanical design department and in the documentation department the Milestones are displayed on notice-boards and thus can be considered to have a visual impact. In the departments of engineering this is not the case, and even though they are sometimes displayed in staff meetings some of the employees are not exposed to the results at all. For the aware employee the reports are available on of the server, but you have to know what you are looking for. In general the system fulfils this recommendation, but it could still be improved (more on this subject in 6.4.3)

14) Be objective – not based on opinion

That the Milestones should be objective is of great importance in the work with improvement of the process. If something is not working according to expectations it should appear in the measuring. As for right now most of the Milestones can be considered objective. The 'Delivery Accuracy Milestone' though involves too much evaluation to be a good measure of performance. Rather than the current state of things, the planning should be changed so that this measure comes down to a simple comparison of two dates. Overall the system fulfils this recommendation.

15) Be consistent (in that they maintain their significance as time goes by)

The system has looked more or less the same for one year and though the production layout has changed since, the measurements still remain significant. The work behind identifying proper measurements has been extensive and they are well thought through to focus on key elements/activities in the process. The reason that mechanical design has been marked with yellow is because the way of measuring it changed by January 2009. The results have since been significantly lower indicating that the previous results are not comparable. In general the system fulfils the recommendation.

6.3.4 Group 3: Improvements

The evaluation is presented in Figure 6-8 below, followed by comments.

Levels of evaluation T = True S = Somewhat true U = Untrue	**16) Focus on improvement**	**17) Closed management loop**	**18) Quantities influenced by users**	**19) Be based on trends**	**20) Provide information**
Confirmation of Order Received	S	T	T	S	S
Order Confirmation	S	T	T	S	S
BoM ready	S	T	T	S	S
Material, Confirmed date	S	U	U	S	U
Material, Requested date	S	T	S	S	U
Mechanical design	S	T	T	S	S
Pipe bending	S	T	T	S	S
Welding	S	T	T	S	S
Assembly	S	T	T	S	S
Wiring	S	T	T	S	S
Automation programs	S	T	T	S	S
Test	S	T	T	S	S
Packing	S	T	T	S	S
Fulfilment of Customer Request	S	T	T	S	S
Orders with dates entered	S	T	T	S	S
Delivery Accuracy – R/3	S	T	T	S	U
Input for Documentation compiling	S	T	T	S	S
Documentation	S	T	T	S	S
Documentation, New machines only	S	T	T	S	S
Delivery Accuracy	S	T	T	S	S

Figure 6-8 Evaluation of measurement system: Improvements

16) Focus on improvement

The New Milestones are clearly an initiative to improve the current process, but falls short on the fact that it has not been able to provide information on what to improve. In order for the system to be a natural source of feedback it needs to be complemented. As an overall summary of the process performance it works well, but to be reliable the issues identified must be evaluated and dealt with. The system thus somewhat fulfils this recommendation.

17) Be part of a closed management loop
Being part of a closed management loop, the authors have chosen to define as whether or not the responsible managers for each of the Milestones have the means to affect the results. Based on and the interviews and the way improvement work is conducted, there are no apparent reasons to why this should not be the case. The only Milestone not following this would be 'Material, Confirmed date' since this measures the suppliers performance, and indirectly the work of Central purchasing, which is outside of BU DBF. The authors' evaluation is that the recommendation is followed.

18) Be based on quantities that can be influenced or controlled by the users
Since most of the Milestones are connected to the work conducted in the process in Lund, the users should be able to influence them. Having said this, the definition of the user needs to be addressed. In this case the authors would like to define the user as the responsible manager. The 'Material, Confirmed date Milestone' cannot be influenced by the users, since it is measuring the performance of the suppliers. The 'Material, Requested date Milestone' can only in part be influenced by the users. The actual delivery is up to the supplier, but the existence of these orders should be minimized. In general the awareness of the measuring should be increased among employees and they should be encouraged to take responsibility for the results. Before this is done it is important that the design and measuring issues are handled so that the results are reliable. To a great extent the recommendation is followed.

19) Be based on trends rather than snapshots
Since the measuring is done regularly and following orders that were delivered in a certain period in part the measurement could be seen as focusing on trends rather than snapshots. On the other hand there is no comparison made between months in the presentation of the results and thus there is no immediate display of the development over time and in which direction the results are moving. To implement this as a complement would be a relatively easy task. The recommendation is only followed in part.

20) Provide information
The question whether the measurement system provides information or not is hard to answer because it has to be connected back to the initial purpose the measuring. The system obviously, if correctly executed, shows the flow of orders through the process and enables the user to point out key areas of improvement. On the other hand, it is hard (based on the authors own experience) to connect the results to the causes. Unless the results of the New Milestones can be connected with results from other measurement systems to provide the total picture it is hard to determine any corrective actions. One idea could be to regularly (every 6 months or so) break down the Milestone on the basis of food category and products. The Milestones marked with red are further at the moment not providing any information at all that could be used to improve the process. The recommendation is only followed in part.

6.3.5 The status of the current system

The New Milestones measurement system was developed using something similar to a 'Needs led/Facilitator led' model. The master thesis on the other hand can be seen as an 'Audit led/Consultant led' model, since it is an evaluation of the current measurement system. With two different models applied the results and priorities will indeed be different, and the results and recommendations presented in this report should only be seen as a guide to the management team who makes the decisions.

General strengths and weaknesses of New Milestones

Evaluated from a very wide set of criteria the system have, as can be seen in the results above, both strengths and weaknesses. The *strengths* are mostly related to the purpose of the measures and presentation of the results. Since the development of the system was handed down to managers who know the process and its characteristics most of the measurements are very relevant. Most of the measurements are objective and the proper authority to change and improve lie with the users and their managers. Since there are separate food categories there exist a great opportunity to use pilot studies and expand them in the case of success.

Based on the analysis made above the best performing Milestones individually are the automatically collected ones that relate to the workshop activities.

The *weaknesses* of the system are primarily, and a bit surprisingly, related to the timeliness and accuracy of the feedback, and also to the involvement of customers and suppliers. Both the manually and the automatically collected measures needs to be revised to ensure that the design and the measuring procedures are correct. A big problem is the amount of missing data for the manual Milestones and to base decisions on these is a huge risk considering that the true value is unknown. Another weakness is the fact that the results are not providing enough information to be used for improvements. Improvement work also requires that the feedback is faster and could be related to specific short term goals.

Likewise based on the analysis above the worst performing Milestones are related to the fulfilment of customer request and the performance of the suppliers. Supported by the recommendations of researchers the authors believe that the Milestone system is something that should be discussed with external partners to ensure that they are supporting a process that provides what is requested of it.

The most prominent issues

In Table 6-22 all the found issues related to each Milestone are listed. These are touched upon in detail in Appendix J, while this chapter will discuss the most prominent ones.

Table 6-22 Summary of issues with New Milestones

Milestone	Issues
Confirmation of Order Received	▪ Incorrect calculations ▪ Missing data
Order Confirmation	▪ Incorrect calculations ▪ Missing data ▪ Time not "frozen"
BoM ready	▪ Missing data ▪ Incorrect reporting procedures ▪ Revisions ▪ The right measure?
Material, Confirmed date / Material, Requested date	▪ Not focusing on the process performance ▪ Not based on the correct data set
Mechanical design	▪ Not based on the correct data set
Pipe bending	▪ No data available ▪ Non-exact data ▪ Data handling errors ▪ Calling the operations in different ways
Welding / Assembly / Wiring	▪ Reporting of rework ▪ Non-exact data ▪ Reporting upgrades ▪ Calling the operations in different ways
Automation programs	▪ Missing data ▪ Orders that do not require automation program are measured as 'Missing information' ▪ Revisions
Test / Packing	▪ Non-exact data/ Test operators cannot report the activities by themselves ▪ Reporting upgrades ▪ Reporting orders from another production plant – Cold plant (Packing only)
Fulfilment of Customer Request / Orders with dates entered	▪ Missing data ▪ Misleading name ▪ No apparent relevancy ('Orders with dates entered')
Delivery Accuracy - R/3	▪ Irrelevant
Input for Documentation compiling	▪ Missing data
Documentation/ Documentation, New machines only	▪ Data collection procedure ▪ Second hand data ▪ Incomparable data ▪ Historical data
Delivery Accuracy	▪ 'Delivery accuracy' does not compare the same days as 'Delivery Accuracy - R/3' ▪ Based on opinions rather than objective facts.

At present the first two Milestones are not measuring what was intended. Measuring days instead of working days when working with tight deadlines has, as has been proved, significant impact on the results. A major issue with the 'Order confirmation Milestone' is that the system cannot handle a long clarification phase and no matter if the problem lies

with the MC or BU DBF the order will be measured as late. This issue can only be resolved through the introduction of a 'Date of clarification' to the measurement system.

An issue primarily related to the 'BoM Milestone' and the 'Automation milestone' is ambiguities in how to handle revisions and changes. Researchers stress the importance that measurements should be clearly defined, and this includes handling every type of possible scenario. A simplified way to deal with multiple revisions would be as follows. If a revision was requested by the customer a new planned date should be added, if the revision was not requested then the old planned date should remain. In both cases the planned date should be compared with the ready date of the last revision. Another issue is that some machines do not require a new automation program, which is something that the system cannot handle in an efficient way. These orders should not be included in the measuring of the 'Automation Milestone'.

In relation with the ordering of components it has been identified that the Milestones called 'Materials, Confirmed date' and 'Materials, Requested date' are not measuring what was intended. These problems could be related back to the sin '*laziness*', presented by Hammer, since there has not been made any controls on whether or not they were measuring what they were intended to. Since measuring what was originally intended is rather hard, the authors' recommendation is that alternative measures should be considered.

All the measurements made in the workshop are handled in the same way. They are taken from R/3 and put through several filters. Unfortunately this treatment does not guarantee that the data presented is what was intended. The recommendation is that the filters are adjusted based on our findings.

The 'Fulfilment of customer request Milestone' is not in any way related to the actual performance of BU DBF and a redesign should thus be considered. The issue with 'Delivery Accuracy' is that it is based on opinion rather than objective facts. It is important that the measures do not leave any room for subjectivity because then the results can be altered to show a desired performance. This is related to '*vanity*', the first 'sin' presented by Hammer.

To sum up the most important issues related to the Milestones, Table 6-23 below is put together. It is similar to the matrices used above, but instead of recommendations on the horizontal axis the most evident issues have been included. These are further grouped into design issues and measuring issues.

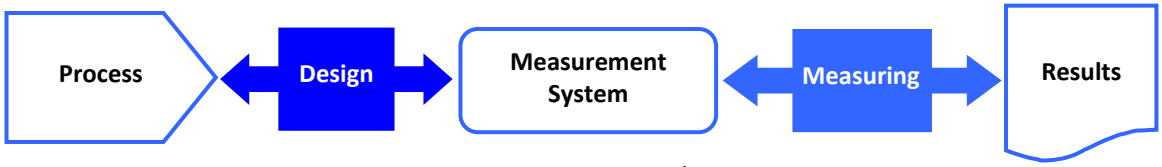


Figure 6-9 Two main issues with measuring

The 'Design issues' are in need of a structured evaluation and a deeper analysis on how they could be resolved. The persons best suited to deal with this are the original developers and to some extent the users. The extent of manual measuring is probably the design issue that in the long run could have the biggest impact on improving the credibility. Another important issue is to make sure that the measures really reflect the performance of the process, which means that the process specification needs to be considered.

The 'Measuring issues' are of a more operational nature, and thus should be more at hand in dealing with. To improve the availability of data is one of these issues, and to make sure that this data is handled in a correct way is another.

Table 6-23 Measurement System Improvement Matrix

	Design				Measuring					
	Manually measured	Not measuring what is intended	Unclear purpose of use	Unstructured handling of revisions/rework	Missing data >20%	Measuring dates and not workdays	Three days are added to the planned date	Includes upgrades	Includes 'Cold Packing'	**Sum**
Confirmation of Order Received	X				X	X				3
Order Confirmation	X	X		X	X	X				5
BoM ready	X			X						2
Material, Confirmed date		X								1
Material, Requested date		X								1
Mechanical design	X									1
Pipe bending					X		X			2
Welding				X			X			2
Assembly				X			X	X		3
Wiring				X			X			2
Automation programs	X	X		X	X					4
Test							X	X		2
Packing							X	X	X	3
Fulfilment of Customer Request			X		X			X	X	4
Orders with dates entered			X		X			X	X	4
Delivery Accuracy - R/3			X				X	X	X	4
Input for Documentation compiling	X				X					2
Documentation	X							X		2
Documentation, New machines only	X									1
Delivery Accuracy	X									1
Sum	9	4	3	6	7	2	7	7	4	**49**

6.3.6 Possible amendments to the current system

In addition to the changes that have been suggested to each Milestone (in Appendix J) the authors have come up with a couple of suggestions for amendments to the system.

Date of clarification
The clarification of an order is identified as an area of improvement. Since 'Order confirmation' should be calculated based on this date rather than the received date, it must be included. This date should be included in the order form and could for measurement purposes be obtained from here.

Include 6 months rolling average
If a 6 months rolling average is presented in the Milestone diagram the performance of the evaluated period could be put into perspective. If performance is above average then this is an indication on that something was done better than previous months. With good results the average is successively increased, which makes it harder to be surpass. This could be a way to encourage people to work hard and take pride in achieving good results.

Available data, manual reporting
To stress the importance of collecting the data it would be a good idea to have a separate Milestone focusing on this. With the current system it would be easy to implement and calculate for the manual Milestones. To really pinpoint the problem it would be necessary to present the available data for each individual Milestone by itself, but since this would increase the amount of space needed to present the results, it is not applicable. A Milestone focusing on the total amount of data available would give a general indication on whether there is enough data collected for the Milestones to be trusted.

6.3.7 Summary

This study has highlighted that the measurement system has strengths as well as weaknesses. The biggest strengths relate to the purpose and thoughts behind the system, while the weaknesses are related to definitions and measuring. A general recommendation is to revise both the design and the measuring procedures.

In terms of amendments to the current system a Milestone focusing on available data could help reduce the problem with missing data. A new date, "Date of Clarification' should be introduced for the measuring of 'Order confirmation'. Further the presentation of the results should include a rolling average to put the results in perspective.

6.4 Other measurement considerations

In this section some ideas are presented on measuring that go beyond the New Milestones.

6.4.1 Setting short term targets – and to follow up on them

A problem with the New Milestones related to the first part of the process, is that when the results are presented the data is three to four months old. This of course limits the possibility to relate the result to the actual performance of the employees. To better connect the Milestones to the work conducted in the process, an idea could be to do monthly follow ups on 'Confirmation of Order received', 'Order confirmation', 'BoM Ready', 'Automation program' and 'Input to documentation compiling'. The gains from doing this are several:

- Increases pressure to have available data
- The food categories can focus on their own orders
- Enables discussions around the process
- Does not increase the time spent on collecting data

If the data is collected the month after the orders have gone through these activities, then the reporting routines have to be more disciplined in order to have reliable data. The awareness of the measuring can hopefully also help to stimulate the identification of issues. It also enable the food categories to focus on data related to their own orders, which would remove all possibilities to make excuses with regards to what other food categories do and do not do. It also creates the possibility to identify best practice in areas where routines differ between food categories. If there is a meeting related to the Milestones held monthly this could work as a natural forum for the order team to discuss problems and improvement suggestions while the problems are fresh in memory.

Since the Milestones data must be collected at one point or another, the amount of work related to this should not increase much. For the first three Milestones the data could be collected in the same month the activities are performed and when it is time for the orders to be delivered this data could be easily be used for the calculation of the New Milestones for these orders. The only additional work would be to check the Revision and approval list to ensure that there have not been done any revisions to the BoM. The 'Automation program' and 'Input to documentation compiling' could in most cases be collected from the "New Milestone med tilläggsmätningar' since these activities are finished close to when the machines are delivered.

The main benefit of having monthly follow ups would be that short term targets could be set up. One idea could be to set a partial goal to increase the result if the Milestone with 5 % every month. The idea behind this is to focus on improvement rather than the result

itself. If the target remains at 100 % then an increase of 6 %, let us say from 45 % to 51 %, would still mean that the target is missed by 49 %. If the partial goal for each month instead would be to increase with 5 %, then the target is reached, while at the same time spurring the employees to work even harder the next month since sustaining this level would mean that the new target is not reached. The awareness and sense of urgency will probably have a positive effect as such, but if/when improvements decreases in amplitude and figures seem to reach a threshold, the time is right to sit down and in depth analyze which the reasons behind this are. Are there still possibilities to do things better within the departments or is it in relation to others further improvements must be improved? E.g. how much can figures improve for the receiving and clarification phase without improving the competence at the MC?

6.4.2 Feedback system

Another addition that could be made to the current measuring system, and that would work well together with the monthly collection of data, is to report reasons behind delays and thus create a feedback base for the work with improvements. A system similar to either the tagging system or the 'Correction List Data' or a combination should be used for the earlier stages of the process. If every delayed order is acknowledged in the same month it occurred then details could be described and collected. The feedback should be categorized so that actions can be taken when issues are repeating themselves. This would also constitute a great source of input when analyzing threshold situations.

6.4.3 Visibility and communication

In the assembly workshop there are computer screens presenting the daily planning and thus the progress of the orders. In the office environment there is no such support. A similar tool/system could help to create an engagement among the employees while at the same making it possible to track problems and deal with them before the consequences are too grave. The problem related to this is the integrity of the individual employee. Since only one AR, PR etc. is working with each order tracking and displaying it to all would be to display the work of each AR and PR. Whether this is a problem or not is of course related to the consequences and the culture.

The communication of the New Milestones results and the purpose of measuring needs to be better. Some of the employee are not familiar with the New Milestones, and thus has no relation to it, even though their results are connected to their personal objectives. By using the measurements together with collected feedback in regularly occurring improvement discussion the awareness and the usefulness of the measuring would increase.

6.5 *General insights*

In this subchapter the analysis will be taken to a more general level.

6.5.1 Processes and improvement work

To reap the full benefits of improvement projects within an organization such as the adaption of the lean/WCM philosophy the organization must be process oriented. Process orientation is further not an absolute state but rather a ratio and even within this area improvements could constantly be made.

The holistic perspective

When working with improvements in an organization a holistic/systems viewpoint is not only useful, but fundamental. By introducing the extended version of the New Milestones and initiating this master thesis BU DBF has taken a couple of steps in the adaption of this holistic view. With regards to the process several of the issues could not have been discovered if the process had not been gone through from end to end. Some of the late deliveries are most likely linked to the late completion of the BoM, which in some cases can be linked to a long clarification process. Problems in assembly can through the tagging be linked back to pipe bending, welding, late deliveries and mechanical design. These can in their turn be linked to late BoM, faulty templates etc. The problem with tests not being rescheduled stretches back to the complicated planning of production.

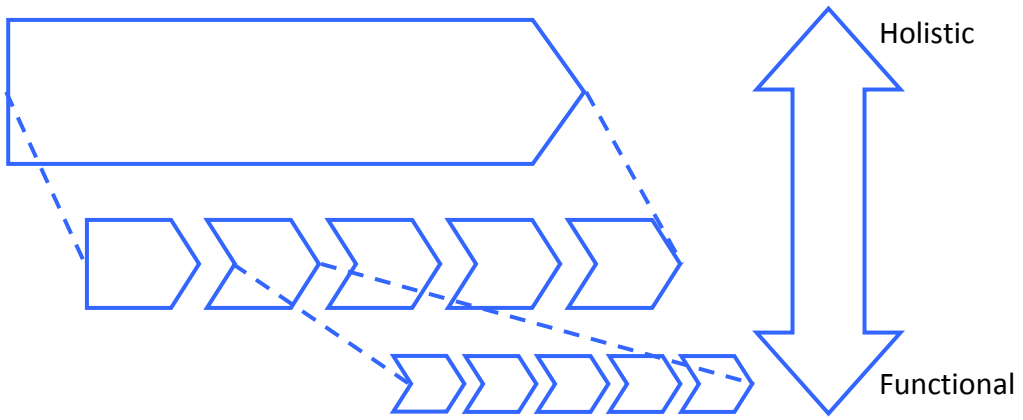


Figure 6-10 The holistic and the functional viewpoint

The functional perspective

At the same time as the holistic view is important to be able to improve the performance of the entire process, the functional perspective is just as important. This is especially true when it comes to determining the reasons for problems that seem to originate from a specific function. Unless the functions perform according to what is decided and communicated this will undermine the general work. In the OFCE-process the clarification phase is not following the process directives, which in some cases causes delays. Another functional issue is how re-planning should be handled in production and test. At the

moment it seems to be non-existent. A smaller but still significant issue is the confusion around when the automation program should be downloaded to the control panel.

It is the authors' belief that the clarification and production planning phases are the two areas within the keys to better performance lie at this moment. Not until clear directives are established and followed is there any point to start working with incremental improvements in line with WCM.

6.5.2 Processes and measurement systems

One of the main purpose of a measurement system is to provide feedback that supports improvement actions (see Figure 6-11). The results must be both relevant and accurate; otherwise the proper corrective actions can be neither identified nor trusted. During the development of a measurement system it is thus important to consider both its design and the measuring procedures. If the results of the measuring do not reflect the process performance, actions based on them will likely bring more harm than good.

Figure 6-11 The role of the measurement system

Design

Faults in the design of the metrics can lead to the introduction of systematic measurement faults. The worst case is when the measurements indicate a better performance than the actual, since this turns focus away from this area. An example from the study is the Milestones connected to the ordering of components. These measures did not measure what was intended and the study revealed issues in this area that were hidden. Since these issues were not pointed out by the measurement system a possible area of improvement was overlooked.

A less grave issue is when the measurement indicates a poorer performance than the actual one or points out problems in areas where they do not exist. This might lead to that resources are spent inefficiently. An example from the study is the catastrophic hit rates for the first Milestones, which did not coincide with employees opinions of the situation. As it turned out the measures were not designed in line with process directives. If the measurements are not reflecting the process being measured employees will soon start losing faith in them.

Measuring
As shown in the study the accuracy of most of the New Milestones is not what it should be. The most prominent reasons for this are the large extent of missing data, late feedback and problems in the measuring routines.

The issue with missing data was mostly concentrated to the manually obtained Milestones. Missing data decreases the credibility of the measure, and the risk of bias is larger. This in turn means that problems could either appear larger than they are or be hidden away. Awareness and proper routines among the responsible collectors are key factors in this area.

The timing of the feedback is important when used for monitoring the process performance. There is little point in analyzing too old data in search for issues, when new ones might have arrived already. Especially when working with people it is important to deal with issues while they are fresh in memory.

The measuring routines are of great importance when collecting data whether this is done manually or automatically. When clear guidelines do not exist or are not followed systematic errors are introduced into the measuring which decrease credibility. Bad measuring routines can undermine good measurement designs.

6.5.3 Measurement systems and improvement work

In order for a measurement system to be classified as excellent, well designed measures and precise results are not enough. These results must be used for driving improvements and decisions and actions should rely on them.

Figure 6-12 Transforming feedback into corrective actions

Collecting feedback and acting on it
An issue with many measurement systems is that they normally point out in which area the problems occur but do not indicate the reasons behind them. Consequently, many measurement systems need to be complemented by other tools that determine the causes. An excellent example of such tool used in BU DBF is the 'Correction List Data' were the reasons of the faults identified in test are reported together with the time lost due to these. In the workshop the tagging system fills a similar function. Unfortunately the clarification

phase of the OFCE-process does not have such a tool which makes it very hard to retrieve the reasons behind why certain activities are late.

In relation to the above it is important to acknowledge that it is not enough to have a measurement system supported with feedback from several different tools. It is just as important for the organization to identify the employees responsible of acting on the information, and give them clear incentives to do so. The responsible persons should collect the feedback from the tools and drive the corrective actions. At the moment the information in the 'Correction List Data' unfortunately does not seem to be used to any greater extent.

Communication and targets

A great step towards any improvement is awareness. The communication of the results of the measuring is as important as the measurement system itself. When interviewing employees and managers throughout the process a striking observation is that the awareness is surprisingly low. The persons that were not properly introduced to the system and its purpose of course could not connect the results to their performance.

Setting targets is necessary as they allow the employees to know how well they have met their objectives. They are also very useful as drivers for improvements. For the New Milestones there are neither any short or midterm goals for any of the Milestones, except for 'Delivery accuracy', nor is there any indication on trends compared to previous months or an average.

7 CONCLUSIONS

This chapter summarizes the most important findings presented in this report and connects them back to the original problem discussion. It further in short discusses the credibility of the study.

7.1 Conclusion on the case

To conclude the report a recap of the initial problem discussion is made below.

- *Are there any deviations from the documented process description in how the daily work is carried out? If this is the case, are these deviations causing problems?*

After describing and analyzing the OFCE-process it was possible to determine the existence of a couple of deviations from the process directives. During the clarification phase the proper form for sending 'Confirmation of order received' is not always used, making it hard to keep track if this activity is performed in time or not. Another issue likewise in the clarification phase is that time is not always 'frozen' when an order is unclear. All the time spent on clarifying the order after the 'technical clarification meeting' has been held should be added to the planned delivery date, but unfortunately this is rarely done. When it comes to the engineering of the modules the directives around the handling of changes are not always followed. Since changes are frequently occurring, the potential impact of such a deviation is large. In the testing phase the routines around preparatory and follow up meetings are not always followed.

The authors' general recommendation related to all the above deviations is to start following the process. If there are problems with the process design these will show once the process is followed and these can then be dealt with in a structured way. Not following the process can serve both as a source of problems as well as a way to cover them up. In general the process design seems to be followed and most parts of the process are working at a very satisfactory level. The majority of the problems that arise throughout the OFCE-process are order specific, due to the wide range of different machines and to the high level of customization that is allowed. Introducing and fully establishing the M1/M2/M3 project will in this respect most likely be beneficial to the performance of the process. By standardizing and modularizing the products it will become easier to find and deal with general problems.

- *The Milestones are not met to a sufficient degree and the causes behind the delays are not known. What are the causes and how could they be dealt with?*

One part in the low scores of the Milestones is the delays throughout the process. The order clarification phase in many cases takes too long time and thus this affects the following phases. The reasons behind this are in part related to complicated customer requests, insufficient competence at MCs, unclear order forms and deviations from the process procedures. A broad effort is needed here involving both sides of the handover between the MC and BU DBF. The initial steps involve start following the process directives, and collect feedback on incorrect filled out order forms.

During the engineering phase once again many problems appeared to be order specific, but it was possible to determine that the BoM frequently was late. To have a complete and correct BoM done in time is difficult due to the high level of customization. This means

that the BoM often require revisions, which could be done weeks or months after the planned ready date in turn affecting the work performed in the downstream phases of the process. To be able to reduce the number of revisions of the BoM a first step would be to register the reasons behind them in a database (similar to the Correction List Data). This information could then be used to identify the most frequent problems and work with improvements could be prioritized based on this.

When it comes to the ordering of components the first identified problem was that some components were requested with a shorter delivery time than agreed in the contract. In some cases it is impossible for the suppliers to meet the requests made and thus this affects the planning of the production activities. At the same time, the suppliers occasionally confirm a longer delivery time than agreed in the contract, which then demands a re-plan of the production operations and ultimately delays the order. The third issue identified is that the suppliers sometimes deliver later than their confirmed dates, in some cases delaying the production of the order. In order to eliminate these problems BU DBF should strive against integrating processes with the most important suppliers. A more short sited approach would be to start using incitement, for deliveries on time, and fines, for late deliveries.

In the testing phase, delays could be connected to reasons in previous phases of the process. In average 11.6 hours are spent per machine correcting problems mostly related to the automation program and the assembly of the machine. Testing produces a lot of feedback and in order to reduce the time spent on correcting problems would be to try to identify and eliminate the root cause of the problems using the existing information (Correction List Data).

- *The results of the measuring system tell a tale of an inefficient process. Could these results partly be a consequence of an inefficient and complicated measuring system? Could the measuring system be improved to better serve its purpose?*

The OFCE-process has as mentioned above some issues pointed out by the measurement system. However, the bad results indicated by the 'New Milestones' are also related to some flaws contained within the measurement system itself. The majority of these problems can be corrected without any larger changes to the current system.

In the clarification phase 'Confirmation of Order received' and 'Order confirmation' are both indicating a much worse performance than what is the case. For 'Confirmation of order received', since the document related to this is not always used, most of the orders are missing information. The recommendation here would be to start using the proper document when responding to the MC. The 'Order confirmation Milestone' is not showing the real process performance since it does not take into consideration the clarification phase of the order. A suggestion on how to deal with this problem would be to compare the days between the "clarification date" and the date when the 'Order

confirmation' is sent, instead as now between the date when the order was received and the latter.

In the engineering phase the 'BoM Ready' and the 'Automation program' Milestones are both affected by ambiguities on how the revisions should be handled. Depending on for which revision the ready date is taken the results for these Milestones vary a lot. Here a decision must be made in order to receive reliable results. Another identified issue related to the design of the 'Automation program Milestone' is that the ready date always is planned five working days before the test is started. However, depending on the type of machine the program is not always needed five days before the test, but rather the same day as the test starts. Therefore it should be decided for which products the program has to be downloaded five days before the test and for which not.

During the analysis of the ordering of components it was possible to identify that the 'Material, requested date' and the 'Material, Confirmed date' were not measuring what was intended and thus the results were indicating a far better performance than the actual one. Measuring what was intended is rather complicated, and unless a way around these obstacles can be found, the best option would be to continue measuring these Milestones the same way but to change their definitions and purposes.

The Milestones in the production and testing are automatically measured and thus data availability and data handling is not an issue. Unfortunately, in order to compensate for bad reporting discipline three days are added to the planned date. This, since the activities in production are performed Just-In-Time, has the effect that the credibility of the results is rather low.

The single most important measurement of the 'New Milestones' is the 'Delivery Accuracy' since its measuring the performance in relation to the customer. As for right now, the result is based around a lot of manual evaluations, which greatly influences its credibility. In a longer perspective this measure should be designed so that measuring it comes down to comparing two dates.

7.2 Discussion on the thesis

This section will give some general reflections on the thesis and discuss the credibility of the results seen from the authors' perspective.

7.2.1 General reflections

The case study results do not deviate much from the findings presented in previous research. Process orientation is a long term project that in most cases never ends. New improvement areas appear whenever an issue has been dealt with. The broad initiative to start implementing the lean philosophy in form of WCM falls well in line with this insight, and we believe that Tetra Pak most likely will reap huge benefits from it in the future. The New Milestones, despite being a good measurement system clearly illustrates how hard it is to consider all the important details. If the process and measurement system is going to be

used as benchmark for other facilities in Greenwood and Shanghai, the recommendations presented in this report are worth considering.

7.2.2 Credibility of the results

The credibility of the thesis is generally strong. By selecting theoretical concepts based on the problem description and structuring the whole study around the framework presented in the theory the conceptual validity is maintained.

Methodology and Theory

The material presented in Methodology and Theory is well supported by several well reputable authors and checked for relevancy in a modern context. To help us with this we have had a very experienced supervisor at the university.

Empirical data

The qualitative data is collected through interviews with people throughout the process, in order to ensure that a good underlying understanding. In some cases interviews have been conducted with several persons with the same role to limit the impact of personal opinions. When possible, both sides of a handover have been considered, in an attempt to eliminate the risk of taking sides. Being two people with different background we hope to have ensured that a wider perspective have been used when developing the interview questions. We have also relied on methodology literature to guide us through this process. Too see an example of an interview guide see Appendix K.

In order to ensure that statements are true quantitative data has been collected to complete the description given by the people involved. Most data originate from the R/3 system, but have in some cases been collected from already constructed compilations. We have tried to verify the quality of this data with people using it in their work. Since not all statements could be verified by data, we have tried to be restrictive when drawing conclusions and rather suggest that areas should be investigated further than present a plausible solution as fact.

Analysis and Conclusions

By creating or using frameworks based on the theory literature we believe to have ensured that the analysis does not drift from the general focus of the thesis. Since most of the conclusions drawn coincide with what is presented in academic literature we believe that the external validity is rather high. Of course one has to consider that the approach used was a (single) case study, and therefore consider the context in which the results were obtained.

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9 APPENDICES

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How Mature Are Your
PROCESSES?

You can evaluate the maturity of a business process and determine how to improve its performance by using this table. Decide how the statements defining the strength levels, from P-1 to P-4, for each enabler apply to the process that you are assessing. If a statement is largely true (at least 80% correct), color the cell green; if it is somewhat true (between 20% and 80% correct), shade the cell yellow; and if it is largely untrue (less than 20% correct), mark the cell red.

		P - 1	P - 2	P - 3	P - 4
Design	**Purpose**	The process has not been designed on an end-to-end basis. Functional managers use the legacy design primarily as a context for functional performance improvement.	The process has been redesigned from end to end in order to optimize its performance.	The process has been designed to fit with other enterprise processes and with the enterprise's IT systems in order to optimize the enterprise's performance.	The process has been designed to fit with customer and supplier processes in order to optimize interenterprise performance.
	Context	The process's inputs, outputs, suppliers, and customers have been identified.	The needs of the process's customers are known and agreed upon.	The process owner and the owners of the other processes with which the process interfaces have established mutual performance expectations.	The process owner and the owners of customer and supplier processes with which the process interfaces have established mutual performance expectations.
	Documentation	The documentation of the process is primarily functional, but it identifies the interconnections among the organizations involved in executing the process.	There is end-to-end documentation of the process design.	The process documentation describes the process's interfaces with, and expectations of, other processes and links the process to the enterprise's system and data architecture.	An electronic representation of the process design supports its performance and management and allows analysis of environmental changes and process reconfigurations.
Performers	**Knowledge**	Performers can name the process they execute and identify the key metrics of its performance.	Performers can describe the process's overall flow; how their work affects customers, other employees in the process, and the process's performance; and the required and actual performance levels.	Performers are familiar both with fundamental business concepts and with the drivers of enterprise performance and can describe how their work affects other processes and the enterprise's performance.	Performers are familiar with the enterprise's industry and its trends and can describe how their work affects interenterprise performance.
	Skills	Performers are skilled in problem solving and process improvement techniques.	Performers are skilled in teamwork and self-management.	Performers are skilled at business decision making.	Performers are skilled at change management and change implementation.
	Behaviour	Performers have some allegiance to the process, but owe primary allegiance to their function.	Performers try to follow the process design, perform it correctly, and work in ways that will enable other people who execute the process to do their work effectively.	Performers strive to ensure that the process delivers the results needed to achieve the enterprise's goals.	Performers look for signs that the process should change, and they propose improvements to the process.
Owner	**Identity**	The process owner is an individual or a group informally charged with improving the process's performance.	Enterprise leadership has created an official process owner role and has filled the position with a senior manager who has clout and credibility.	The process comes first for the owner in terms of time allocation, mind share, and personal goals.	The process owner is a member of the enterprise's most senior decision-making body.
	Activities	The process owner identifies and documents the process, communicates it to all the performers, and sponsors small-scale change projects.	The process owner articulates the process's performance goals and a vision of its future; sponsors redesign and improvement efforts; plans their implementation; and ensures compliance with the process design.	The process owner works with other process owners to integrate processes to achieve the enterprise's goals.	The process owner develops a rolling strategic plan for the process, participates in enterprise-level strategic planning, and collaborates with his or her counterparts working for customers and suppliers to sponsor interenterprise processredesign initiatives.
	Authority	The process owner lobbies for the process but can only encourage functional managers to make changes.	The process owner can convene a process redesign team and implement the new design and has some control over the technology budget for the process.	The process owner controls the IT systems that support the process and any projects that change the process and has some influence over personnel assignments and evaluations as well as the process's budget.	The process owner controls the process's budget and exerts strong influence over personnel assignments and evaluations.
Infrastructure	**Information Systems**	Fragmented legacy IT systems support the process.	An IT system constructed from functional components supports the process.	An integrated IT system, designed with the process in mind and adhering to enterprise standards, supports the process.	An IT system with a modular architecture that adheres to industry standards for interenterprise communication supports the process.
	Human Resource Systems	Functional managers reward the attainment of functional excellence and the resolution of functional problems in a process context.	The process's design drives role definitions, job descriptions, and competency profiles. Job training is based on process documentation.	Hiring, development, reward, and recognition systems emphasize the process's needs and results and balance them against the enterprise's needs.	Hiring, development, reward, and recognition systems reinforce the importance of intra- and interenterprise collaboration, personal learning, and organizational change.
Metrics	**Definition**	The process has some basic cost and quality metrics.	The process has end-to-end metrics derived from customer requirements.	The process's metrics as well as cross-process metrics have been derived from the enterprise's strategic goals.	The process's metrics have been derived from interenterprise goals.
	Uses	Managers us the process's metrics to track its performance, identify root causes of faulty performance, and drive functional improvements.	Managers use the process's metrics to compare its performance to benchmarks, best-in-class performance, and customer needs and to set performance targets.	Managers present the metrics to process performers for awareness and motivation. They use dashboards based on the metrics for day-to-day management of the process.	Managers regularly review and refresh the process's metrics and targets and use them in strategic planning.

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How Mature Is Your

ENTERPRISE?

To determine if your organization is ready to support a process-based transformation, evaluate the statements in this table. They show the strength levels, from E-1 to E-4, of the capabilities that enterprises need in order to develop their business process.

If a statement is at least 80% correct, color the cell green; if it is between 20% and 80% correct, shade it yellow; and if it is less than 20% correct, make it red.

		E- 1	E - 2	E - 3	E - 4
Leadership	**Awareness**	The enterprise's senior executive team recognizes the need to improve operational performance but has only a limited understanding of the power of business processes.	At least one senior executive deeply understands the business process concept, how the enterprise can use it to improve performance, and what is involved in implementing it.	The senior executive team views the enterprise in process terms and has developed a vision of the enterprise and its processes.	The senior executive team sees its own work in process terms and perceives process management not as a project but as a way of managing the business.
	Awareness	The leadership of the process program lies in the middle management ranks.	A senior executive has taken leadership of, and responsibility for, the process program.	There is strong alignment in the senior executive team regarding the process program. There is also a network of people throughout the enterprise helping to promote process efforts.	People throughout the enterprise exhibit enthusiasm for process management and play leadership roles in process efforts.
	Behavior	A senior executive endorses and invests in operational improvement.	A senior executive has publicly set stretch performance goals in customer terms and is prepared to commit resources, make deep changes, and remove roadblocks in order to achieve those goals.	Senior executives operate as a team, manage the enterprise through its processes, and are actively engaged in the process program.	The members of the senior executive team perform their own work as processes, center strategic planning on processes, and develop new business opportunities based on high-performance processes.
	Style	The senior executive team has started shifting from a top-down, hierarchical style to an open, collaborative style.	The senior executive team leading the process program is passionate about the need to change and about process as the key tool for change.	The senior executive team has delegated control and authority to process owners and process performers.	The senior executive team exercises leadership through vision and influence rather than command and control.
Culture	**Teamwork**	Teamwork is project focused, occasional, and atypical.	The enterprise commonly uses cross-functional project teams for improvement efforts.	Teamwork is the norm among process performers and is commonplace among managers.	Teamwork with customers and suppliers is commonplace.
	Customer Focus	There is a widespread belief that customer focus is important, but there is limited appreciation of what that means. There is also uncertainty and conflict about how to meet customers' needs.	Employees realize that the purpose of their work is to deliver extraordinary customer value.	Employees understand that customers demand uniform excellence and a seamless experience.	Employees focus on collaborating with trading partners to meet the needs of final customers.
	Responsibility	Accountability for results rests with managers.	Frontline personnel begin to take ownership of results.	Employees feel accountable for enterprise results.	Employees feel a sense of mission in serving customers and achieving ever-better performance.
	Attitude Toward Change	There is growing acceptance in the enterprise about the need to make modest change.	Employees are prepared for significant change in how work is performed.	Employees are ready for major multidimensional change.	Employees recognize change as inevitable and embrace it as a regular phenomenon.
Expertise	**People**	A small group of people has a deep appreciation for the power of processes.	A cadre of experts has skills in process redesign and implementation, project management, communications, and change management.	A cadre of experts has skills in large-scale change management and enterprise transformation.	Substantial numbers of people with skills in process redesign and implementation, project management, program management, and change management are present across the enterprise. A formal process for developing and maintaining that skill base is also in place.
	Methodology	The enterprise uses one or more methodologies for solving execution problems and making incremental process improvements.	Process redesign teams have access to a basic methodology for process redesign.	The enterprise has developed and standardized a formal process for process redesign and has integrated it with a standard process for process improvement.	Process management and redesign have become core competencies and are embedded in a formal system that includes environment scanning, change planning, implementation, and process-centered innovation.
Governance	**Process Model**	The enterprise has identified some business processes.	The enterprise has developed a complete enterprise process model, and the senior executive team has accepted it.	The enterprise process model has been communicated throughout the enterprise, is used to drive project prioritization, and is linked to enterprise-level technologies and data architectures.	The enterprise has extended its process model to connect with those of customers and suppliers. It also uses the model in strategy development.
	Accountability	Functional managers are responsible for performance, project managers for improvement projects.	Process owners have accountability for individual processes, and a steering committee is responsible for the enterprise's overall progress with processes.	Process owners share accountability for the enterprise's performance.	A process council operates as the most senior management body; performers share accountability for enterprise performance; and the enterprise has established steering committees with customers and suppliers to drive interenterprise process change.
	Integration	One or more groups advocate and support possibly distinct operational improvement techniques.	An informal coordinating body provides needed program management while a steering committee allocates resources for process redesign projects.	A formal program management office, headed by a chief process officer, coordinates and integrates all process projects, and a process council manages interprocess integration issues. The enterprise manages and deploys all process improvement techniques and tools in an integrated manner.	Process owners work with their counterparts in customer and supplier enterprises to drive interenterprise process integration.

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9.3 *Appendix C - Products*

Table 9-1 presents the most common products produced by BU DBF.

Name	Function	Processed product
Dairy		
Tetra Therm Lacta	Pasteurization	Market milk, cheese milk, yoghurt milk, cream and ice cream mix
Tetra Alfast	Standardization of dairy products	Milk, cream
Tetra Therm Aseptic Flex	Ultra high temperature treatment	Milk, cream, yogurt, juice, nectar, tea
Tetra Therm Aseptic VTIS	Ultra high temperature treatment with steam injectors	Milk, cream, soy milk, desserts, ESL products
Tetra Alsafe LA	Vacuum storage, buffer tank	All
Tetra Aldose	Dosing of ingredients into aseptic systems	Milk, fresh cheese
Tetra Therm Aseptic Pilot	Smaller version of Flex and VTIS	See above
Tetra Alcross Bactocatch	Micro filtration	Milk
Tetra Almix	Mixer of powder and liquid	All formulated dairy products
Tetra Alcip	Automatic cleaning	All
Tetra Flexdos	Aseptic dosing	Dairy products
Beverage		
Tetra Therm Aseptic Drink	Aseptic beverage pasteurization	Fruit juice, still drinks, nectar, sports drinks, coffee or tea based beverages, fruit juice concentrate
Tetra Alblend	Blending of liquid components	Liquids
Tetra Alwin Tea/Soy	Tea/soy extraction system	Tea/soy
Tetra Albrix C	Continuous dissolving and pasteurization of granulated sugar	Still drinks, confectionery jam, carbonated soft drinks
Tetra Alcarb Spark	Carbonation unit	Soft drinks, other carbonated drinks
Prepared food		
Tetra Therm Aseptic Visco	Indirect ultra high temperature treatment for viscous products	Tomato products, soups and sauces, desserts
Tetra Albatch	Batch processing system	Tomato products, soups and sauces, desserts and puddings

9.4 Appendix D - Abbreviations

There are quite a lot of abbreviations used in relation to describing the process. As a support for reading the process description, they are all presented alphabetically below.

AD	Automation designer
AR	Automation responsible
ASR	Automation Solution Responsible
BoM	Bill of Material
CRP	Coordination responsible production
DPM	Development Project Manager
DS	Documentalist
MC	Market Company
MD	Managing director
MDM	Mechanical Design Manager
OD	Operational director
OFCE	Order Fulfilment Capital Equipment
OP	Operator
OR	Order receiver
ORO	Order owner
PD	Process designer
PM	Product Manager
PPM	Production planning meeting
PPP	Production planning protocol
PR	Process responsible
PRM	Production manager
PSM	Product sales manager
PU	Purchaser
PUA	Purchase assistant
R/3	ERP-system from SAP
SSMB	Sales Support Manager Branded Processing Units
SSML	Sales Support Manager Lines
SSMU	Sales Support Manager Upgrades
TAD	Translation administrator
TE	Technical editor
TMOP	Team Manager Operations
TPM	Technical Product Responsible
TR	Test responsible

9.5 *Appendix E – New Milestones results*

Year	Month	Confirmation of Order Recieved	Order Confirmation	BoM ready	Material, Confirmed date	Material, Requested date	Mechanical design	Pipe bending	Welding	Assembly	Wiring	Automation programs	Test	Packing	Fulfillment of Customer Request	Orders with dates entered	Delivery_Accuracy - R/3	Input for Documentation compiling	Documentation	Documentation, New machines only	Delivery Accuracy
2008	January	21,4%	28,6%	59,5%	76,6%	63,7%	100,0%	87,5%	47,1%	28,9%	43,2%	54,8%	50,0%	79,4%	96,8%	45,6%	33,8%	48,0%	95,8%	100,0%	97,6%
	February	24,4%	12,2%	65,9%	88,6%	79,3%	97,5%			37,3%	50,0%	34,1%	69,2%	80,0%	82,4%	44,2%	28,6%	55,0%	86,0%	100,0%	97,6%
	March	11,4%	11,4%	51,4%	78,6%	70,2%	95,2%			35,1%	60,0%	42,9%	69,4%	74,6%	94,6%	54,4%	41,2%	65,0%	55,2%	94,9%	97,1%
	April	27,7%	23,4%	61,7%	82,0%	72,6%	100,0%			39,6%	58,8%	48,9%	58,8%	70,7%	87,2%	56,6%	36,1%	62,0%	66,7%	72,7%	100,0%
	May	2,1%	14,6%	41,7%	87,9%	76,7%	96,2%	87,5%	47,1%	39,1%	37,9%	37,5%	54,7%	57,3%	80,3%	100,0%	0,0%	50,0%	62,8%	67,3%	91,7%
	June	0,0%	16,7%	54,2%	76,6%	75,0%	97,3%	87,5%	22,7%	22,7%	51,2%	26,5%	63,3%	58,1%	90,6%	51,6%	33,9%	75,0%	65,2%	60,0%	95,7%
	July	0,0%	0,0%	26,5%	84,4%	72,8%	97,5%	87,5%	22,2%	27,7%	26,8%	28,9%	37,0%	36,7%	95,7%	46,9%	18,4%	50,0%	51,8%	78,3%	97,1%
	August	0,0%	15,8%	36,8%	75,5%	75,0%	100,0%	87,5%	14,8%	18,4%	25,6%	25,7%	45,2%	42,6%	96,6%	53,7%	13,0%	42,0%	46,8%	71,7%	94,7%
	September	0,0%	2,9%	40,0%	86,6%	73,8%	95,7%	87,5%	10,2%	23,6%	10,9%	64,9%	31,4%	48,0%	79,5%	58,7%	26,7%	57,0%	70,7%	68,4%	91,2%
	October	0,0%	20,0%	63,2%	88,2%	76,7%	97,3%	87,5%	15,8%	21,6%	39,5%	52,5%	57,6%	66,7%	96,7%	71,4%	28,6%	35,0%	55,3%	83,3%	92,9%
	November	0,0%	17,5%	47,5%	86,2%	71,0%	95,0%	87,5%	3,2%	10,3%	15,7%	29,2%	36,7%	70,4%	100,0%	53,7%	33,3%	59,0%	69,1%	71,4%	95,7%
	December	0,0%	39,6%	56,3%	91,3%	72,8%	100,0%	87,5%	57,1%	50,0%	54,2%	46,7%	68,8%	73,1%	90,9%	42,3%	53,8%	69,0%	69,4%	71,1%	100,0%
2009	January	30,0%	30,0%	56,7%	89,9%	67,1%	93,3%	87,5%													
Average		9,0%	17,9%	50,9%	84,0%	72,8%	97,3%	87,5%	20,9%	29,5%	39,5%	40,5%	53,5%	63,1%	90,9%	56,6%	28,9%	56,1%	66,9%	76,4%	95,4%

= No data available

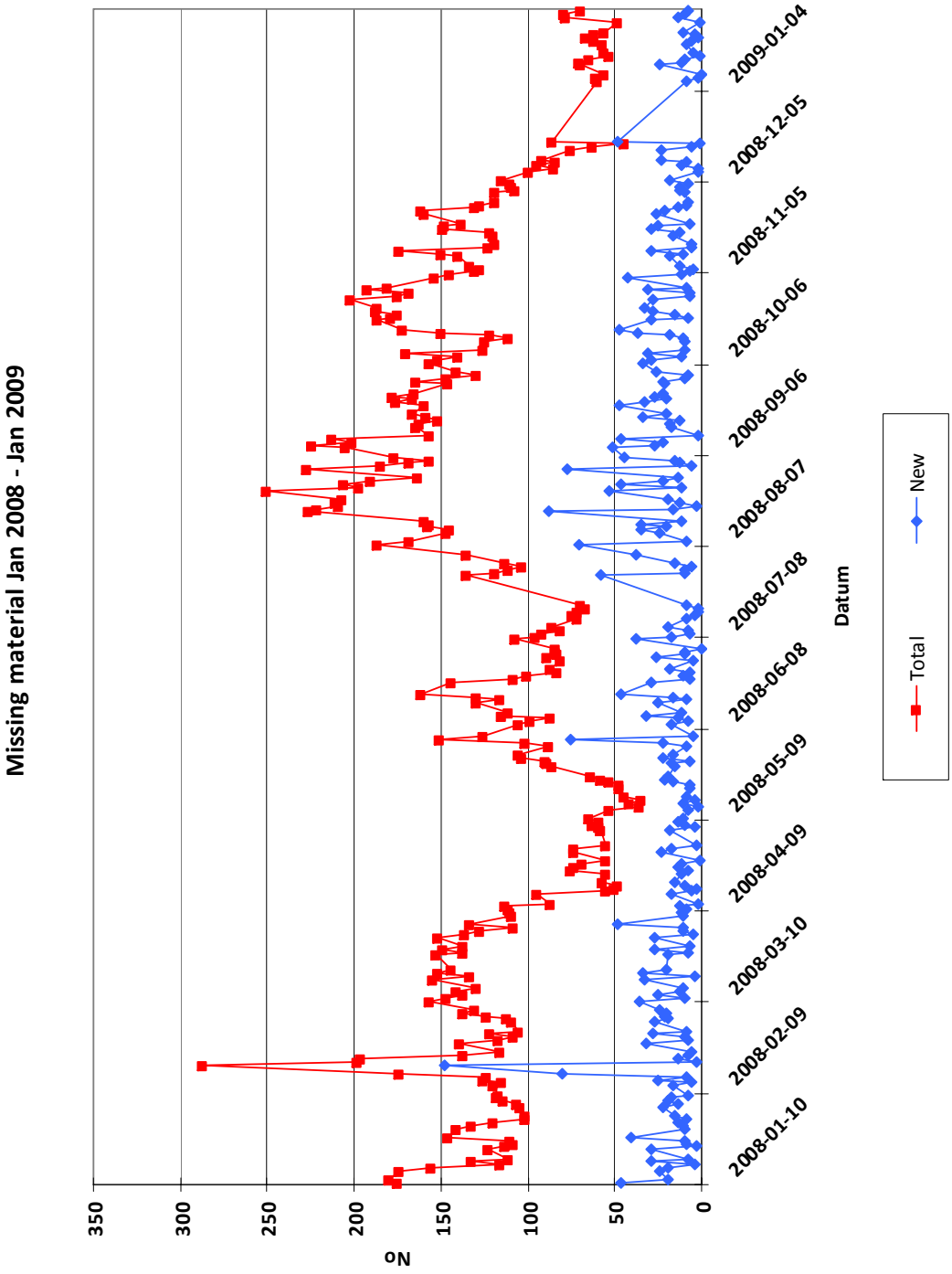
= Possible measuring problem

9.6 *Appendix F – Data for cost calculation*

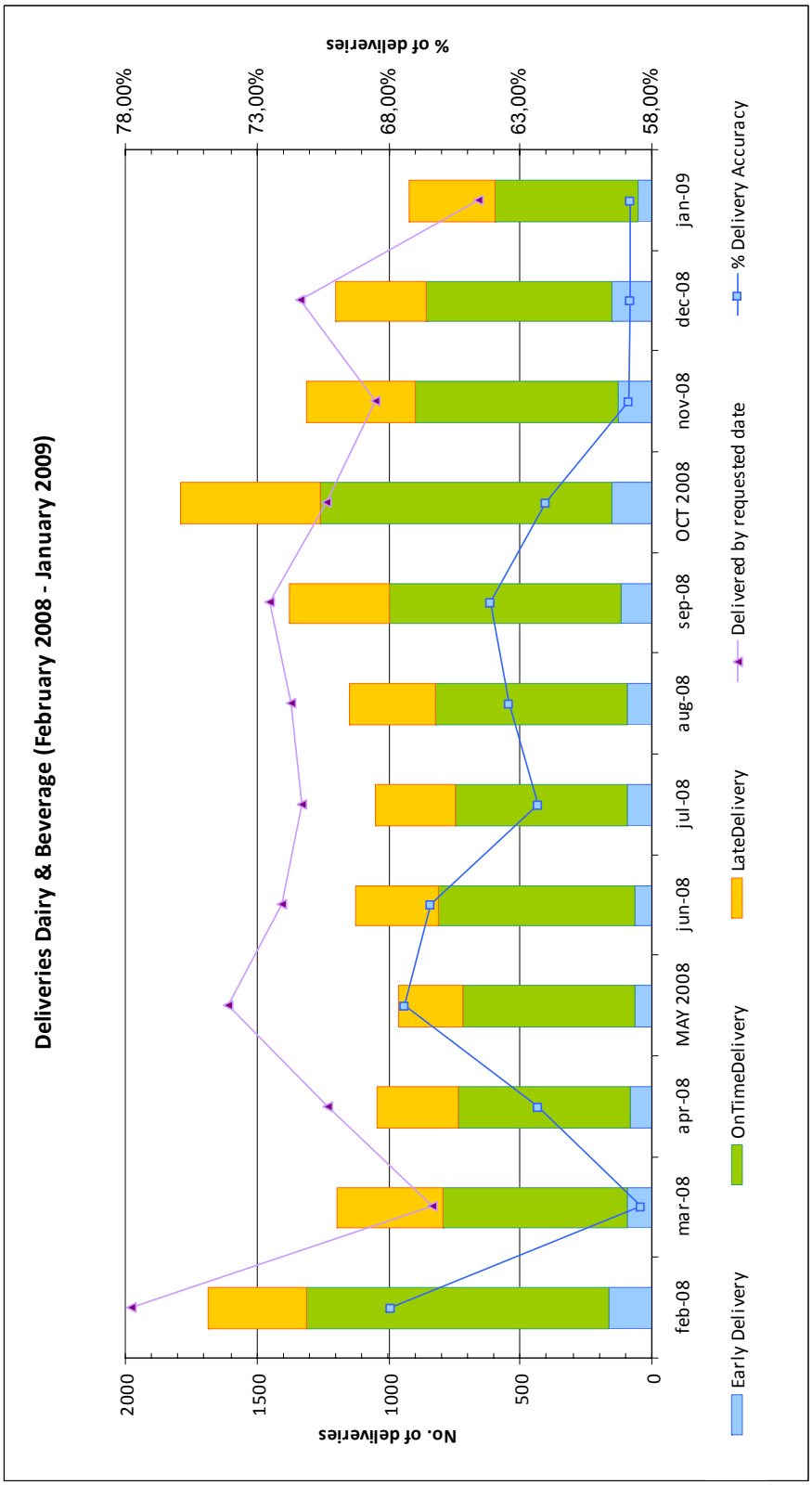
Table 9-2 Data for calculation of the cost of overtime (January 2008 - January 2009).

Activity	Time in hours		Overtime (in hours)	Additional cost
	Planned	Actual		
Admin. Sum	7 818	7 250	-568	-340 800
Assembly Sum	70 331	89 015	18 684	8 968 320
Pipe bending Sum	3 837	4 585	748	359 040
Mechanical design Sum	20 144	24 856	4 712	2 732 960
Process design Sum	21 846	23 781	1 935	1 354 500
Test Sum	26 280	31 275	4 995	4 795 200
Welding Sum	33 866	37 918	4 052	1 944 960
Wiring Sum	19 702	25 736	6 034	2 896 320
Total	**203 824**	**244 416**	**40 592**	**22 710 500**

9.7 Appendix G – Missing components



9.8 *Appendix H – Delivery Accuracy*



9.9 *Appendix I – Detailed causes of delay in test*

Table 9-3 The four most common fault types broken down into subtypes

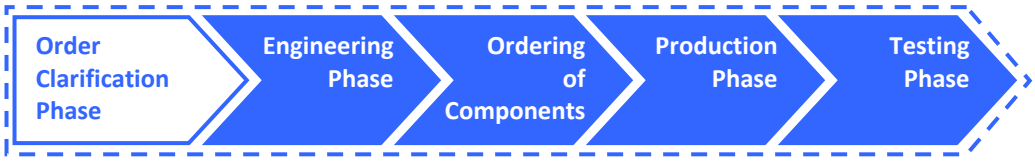
Type of fault	Fault subtype	Sum of time lost (hours)	Number of faults	Average time lost per fault	Percentage of each subtype of fault
Automation	PLC, Program fault	867.7	931	0.9	47,0%
	PLC, Configuration fault	349.4	331	1.1	18.9%
	Other automation fault	182.2	107	1.7	9.9%
	Hardware setup fault	171.3	85	2	9.3%
	HMI, Application fault	150.5	356	0.4	8.1%
	PLC, Missing function	107.8	117	0.9	5.8%
	Automation document	18.1	36	0.5	1,0%
Automation Total		*1847*	*1963*	*0.9*	*100,0%*
Delays	Mechanical assembly delay	259	33	7.8	43,0%
	Electrical installation delay	198.5	24	8.3	32.9%
	Process design delay	42.4	10	4.2	7,0%
	Automation delay	28.6	12	2.4	4.7%
	Electrical panel delay	26	1	26	4.3%
	Other delays	48.1	9	24.7	8,0%
Delays Total		*602.6*	*89*	*6.8*	100,0%
Electrical installation	Cable connection	417.2	510	0.8	69.7%
	Air connection	89.7	234	0.4	15,0%
	Quality of work	42.7	51	0.8	7.1%
	Other faults	48.8	70	1.8	8.2%
Electrical installation Total		*598.3*	*865*	*0.7*	*100,0%*
Mechanical assembly	Assembly	304.4	556	0.5	45.6%
	Leakage	197.9	221	0.9	29.7%
	Other mechanical fault	49.4	40	1.2	7.4%
	Quality of work	45	54	0.8	6.7%
	Utility connections missing	33	36	0.9	4.9%
	Labelling	30.6	232	0.1	4.6%
	Other faults	7.3	36	1.8	0.8%
Mechanical assembly Total		*667.4*	*1175*	*0.6*	100,0%
Grand Total		**3715.3**	**4092**	**0.9**	

Table 9-4 Faults January 2008-May 2009 sorted on machines

Module	Faults identified in test		Time lost due to faults	
	Number of faults	Percentage of total	Sum of time (hours)	Percentage of total
TA VTIS 100	638	12.2 %	685.1	13.0 %
TA Flex 10	665	12.7 %	662.2	12.5 %
TA Drink 10	650	12.4 %	568.6	10.7 %
Tetra Alsafe LA	513	9.8 %	463.7	8.8 %
TA Drink 100	356	6.8 %	323.3	6.1 %
Tetra Therm Lacta 100	240	4.6 %	234.9	4.4 %
TA Flex 100	232	4.4 %	231.5	4.4 %
Tetra Therm Lacta 10	221	4.2 %	211.3	4.0 %
TA VTIS 10	208	4.0 %	209.4	4.0 %
Tetra Alcip 100	185	3.5 %	204.7	3.9 %
Tetra Albrix	168	3.2 %	142.4	2.7 %
TA Visco 100	159	3.0 %	135.8	2.6 %
Tetra Alcip 10	132	2.5 %	134.4	2.5 %
TA Flex 1	113	2.2 %	128.4	2.4 %
Total	**4480**	**85.5 %**	**4335.8**	**82.0 %**

9.10 Appendix J – Milestone by Milestone

9.10.1 Order clarification phase



Confirmation of order received

Issues

- Calculations were done incorrectly
- Missing data

The first issue is rather a quick fix which only demands some knowledge of MS Excel. By changing to a formula that only counts working days the measurement is now working as it should, and the old data can be recalculated to better illustrate the situation of previous months.

The second problem is of a somewhat more serious nature. Data for this measure is obtained manually and the responsible for doing this is the Manager of Sales Support (MSS). A further breakdown between Dairy, Beverage and Prepared food shows that no data is reported from Beverage indicating that no measuring has been conducted.

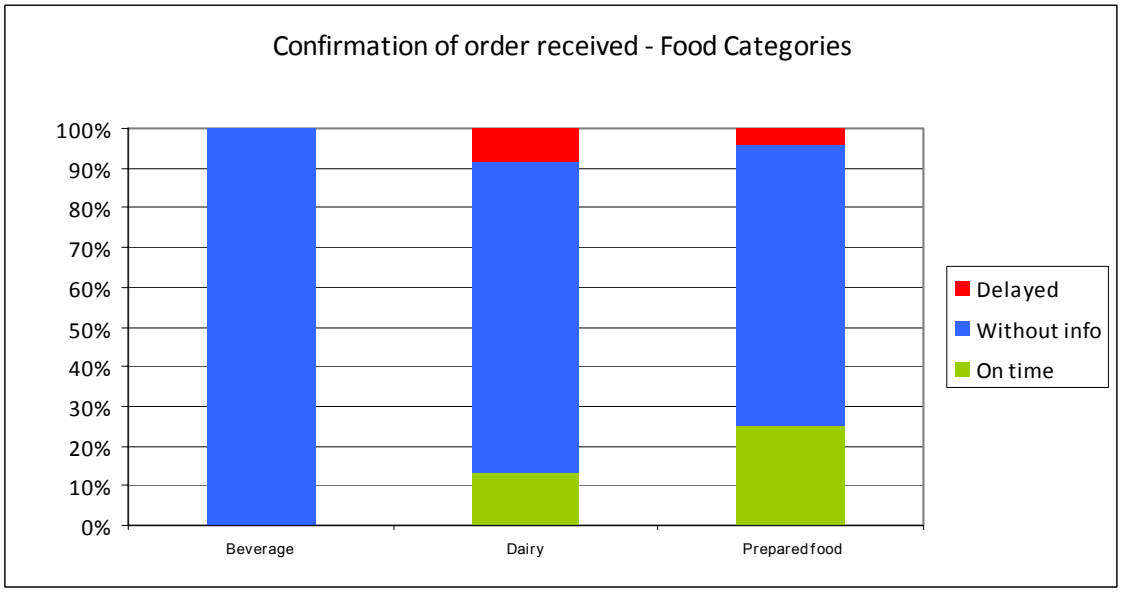


Figure 9-1 Available data for 'Confirmation of order received'

Since Sales Managers are allowed to work according to their individual preferences and that the appropriate document is not always used could explain to why the amount of available data is so low. Another possible reason is that since the MSS did not belong to the team that developed the New Milestones they are not aware of it and what is expected of them. This is likely to be the case with Beverage since they have never measured this. There also exist orders were the 'Confirmation of order received' document was available in the order folder but it was not reported in the measurement system.

In order to come to terms with this problem proper directives and standards should be developed, and MSS should ensure that these are followed.

Order confirmation

Issues

- Calculations were done incorrectly
- Missing data
- The time should be "frozen" when an order is unclear

The first problem can be solved using the same change of formula employed for 'Confirmation of order received'.

The second problem, missing data, is present in more than 20 % of the orders. Data are obtained manually from e-mails sent to the MC, and the reason behind the missing data is that the e-mails were not added to the order folder.

The third problem is the most serious of the three and also more complicated to solve. The fact that the date for clarification is not measured in the system, results in that almost every order that need some kind of clarification runs the risk of being measured as late, even in cases when it should not be according to directives.

When taking a closer look at the saved correspondence of some of the late orders it appeared clear that for some of them that if the time had been stopped then the 'Order confirmation' for it would be on time instead of late. As an example we can take an order that was received from the MC the 200X-03-31 and with the 'Order confirmation' sent the 200X-04-25, i.e. with more than ten working days between the dates. However, the clarification date for the order was 2008-04-16 and if this date would have been taken in to consideration in the measurement system instead of the received date the order would have been considered as on time. How often this is the case is hard to determine since correspondence is not always complete for all orders.

The solution to the issue (as suggested in 6.3.6) would be to instead of using the order received date as a base for measuring the 'Order confirmation Milestone', the *order clarification date* should be used. This demands that a uniform definition of this date is

established. If correspondence is saved it the receiving date of the last mail from MC with further information could be used for this purpose. The measure should compare this date with the date for sending the order confirmation, and the difference should according to the agreement be no more than *seven* working days.

BoM Ready

Issues

- Missing data
- Incorrect reporting procedures
- Revisions
- The right measure?

The first problem reduces the credibility of the results of this Milestone. Almost 15 % of the data are missing for the period between January 2008 and January 2009.

The second problem, the possibility of incorrect reporting procedures, is a factor that affects the credibility. The PR should always report the actual ready date of the documents and not the date of reporting. This issue should be relatively easy to fix by making sure that everyone are aware of the process measurements and how they are calculated.

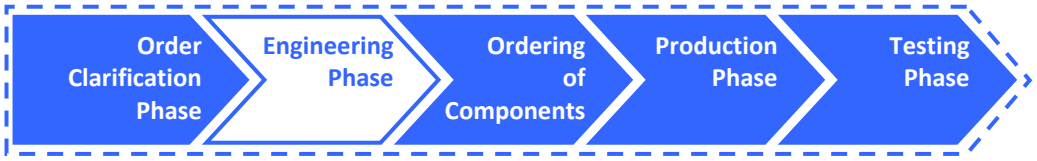
The third problem relates to the handling of revisions. The specification of the Milestone does not explicitly state which date should be used as the actual ready date if there has been made revisions to the BoM. A suggestion is presented below..

a) *Revisions due to requested changes to the order* – When a change is requested to be made to an order, the process dictates that the variation order procedure should be used. The new planned finished date should be added to the PPP document and it should be compared in the measurement system to the reported finishing date of the last revision.

b) *Revisions when no changes were requested to the order* – When a revision is done because of other reasons than changes in the customer requests the ready date of the last revision should be compared to the planned ready date from the original PPM.

A question that must be brought up in this context is whether the time is the right/only way the BoM should be measured. The impression the authors have got is that it in most cases seems to be more important to have the BoM correct than ready on time, since changes are cumbersome to handle. An idea would be to complement this measure, with a measurement that focused on *quality* of the BoM.

9.10.2 Engineering phase



Mechanical design

Issues

- Not based on the correct data set

During 2008 the results for the 'Mechanical design Milestone' were really high (see table below).

Table 9-5 Results for Mechanical design 2008.

Average	Standard deviation
97.6 %	1,90%

However, these excellent results can be questioned since the measuring procedure deviated from the directives stated for the New Milestones. The reasoning behind this was to obtain comparable results for all months of 2008, since these old procedures for measuring had been in use from the beginning of the year. The old system unfortunately was based on indications by the designers rather than facts.

From the start of this year, the 'Mechanical design Milestone' is measured as intended and the average from January to March are presented below. This result indicates that their counterparts from 2008 overestimated the performance.

Table 9-6 Results for Mechanical design 2009.

Average	Standard deviation
85,30%	7,54%

The above analyzed measurement includes the performance of the people in the Mechanical Design department and also the mechanical designers in Dairy who designs the drawings for Alcip, Alfast, Almix and Aldose. Separating the performance between these two groups of designers for January and February of 2009 generates the following results:

Table 9-7 Comparison of the Mechanical design department and other mechanical designers

	On time	Without info	Late	Total	% on time
Dairy mechanical designers (Alcip, Alfast, Almix and Aldose)	11	1	4	16	68,8 %
Mechanical Design Department	35	2	2	39	89,7 %
Mechanical Design Milestone	**46**	**3**	**6**	**55**	**83,6 %**

From the data above we can observe that the performance of the Mechanical Design department is significantly better than the average of mechanical design. The mechanical design performed in Dairy on the other hand needs to improve. The mechanical drawings are indispensable during the production phases, and hence not meeting the planned date could affect the beginning of the production activities.

Automation program

Issues

- Missing data
- Orders that do not require automation program are measured as 'Missing information'
- Revisions

The first problem reduces the credibility of the results of this Milestone. Almost 30 % of the data are missing for the period between January 2008 and January 2009.

The second issue affects (as could be seen in the empirical part) at least two machines that do not need a new automation program for every new order. These orders at the moment measured as 'Missing information'. Further there were some orders that had "NA" entered in the cells instead of dates, which also gave un-accurate results. To avoid these problems in the future we suggest the following.

a) *Production planning protocol* – In this document in the cell where the 'Automation planned ready date' should be, the ORO should enter 'No automation is required'

b) *Revision and approval list* – In this document in the place where the actual ready date of the automation should be reported, the AR should enter 'No Automation is required'

c) *Measurement system* – After the TMOP have identified the orders that do not required an automation program to be made they should in the file "New Milestones med tilläggsmätningar.xls", for each of these orders, delete the formula in the cell for Automation related to that order.

The third problem is the same as the one presented for the 'BoM Milestone' and it is related to ambiguities on how revisions should be handled in the measurement system. The same recommendations as for the BoM apply.

Input to documentation compiling

Issues

- Missing data

In almost 13 % of the cases the data is missing, which of course decreases the credibility of the measure.

Documentation and Documentation, New machines only

The procedure in obtaining these measures seems to be well defined and no obvious problems are present. Four minor remarks should be made though:

Issues

- Data collection procedure
- Second hand data
- Incomparable data
- Historical data

The first issue is related to the collection of data for 'Documentation'. The data are taken from the FLOWTS system and involves manual counting and calculations. A natural step in the development of the measurement system would be to try to integrate this into the R/3 system.

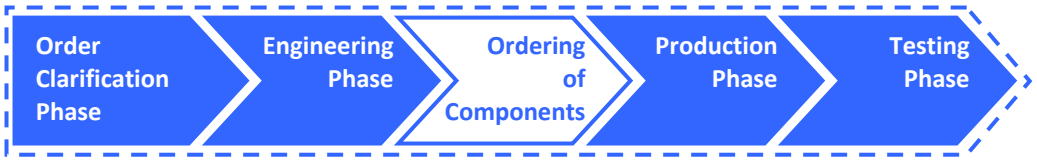
The second issue relates to the 'Documentation, New Machines only Milestone', for which data is obtained from the file "Problemrapportering.xls". In this file the documentalist fills in whether the order was on time or not (i = in time, d = delayed) and this is then used for the calculation of the Milestone. The exact dates are not seen here, and there is a risk that the same problem could be present here as for the 'Mechanical design Milestone'.

The third issue is that some orders seem to appear in different months in the data for 'Documentation, New machines only' compared to the other manually collected Milestones. The reason behind this should be determined.

The fourth issue involves both the documentation Milestones, and is related to the following up of old orders. As for right now dates can fairly easily be obtained for all other Milestone by looking in an Excel-file, but for documentation one has to access the

FLOWTS system. If the data were put into R/3 and treated the same way as the automatically obtained Milestones, this would not be a problem.

9.10.3 Ordering of components



Materials, Confirmed date and Materials, Requested date

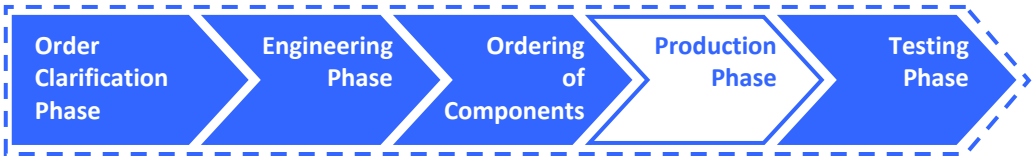
Issues

- Not focusing on the process performance
- Not based on the correct data set

The first problem is related to the 'Materials, Confirmed date Milestone'. As mentioned in 5.2.1 it is not very well adjusted to the process, and is not following its specification. When the suppliers do not follow the contract in a lean manufacturing system, there will be needs for re-planning of the production activities. If the suppliers are confirming the delivery of the components whenever they want then it would be impossible for BU DBF to follow their production planning and to deliver their products without using extra resources. The 'Materials, Requested date Milestone' can as it works today be interpreted as the total impact that the delivery of components have on the process.

From discussions with the responsible people it has come clear to us that measuring what was originally intended might not be a very simple affair, and an alternative to changing the measuring could be to change the purpose of the measure. The 'Materials, Confirmed date Milestone' could focus on the evaluating how well the suppliers following their obligations, while the 'Materials, Requested date Milestone' could focus on the impact on the process. The problem with this order would of course be that it does not provide as much information as the intended measurements would.

9.10.4 Production phase



Pipe bending

Issues

- No data available
- Non-exact data (see Welding, Assembly and Wiring below)
- Data handling errors
- Calling the operations in different ways

The first issue can be seen from January 2008 to January 2009. The results presented in the New Milestones do not correspond to the performance of the pipe bending operation. During these months the 'Pipe bending Milestone' was not measured and instead a fixed value, 87.5 % was used.

The third bullet can be seen during the months of February and March 2009, where the data collection has started. The reported results for these months are hit rates of 100 %. However, this is not correct since the formula used to calculate this Milestone was incorrect. Instead of comparing the number of orders that were on time with the total number of orders, it compared the number of orders that were on time with the number of orders that were on time, hence the result 100 %. The real result for February and March can be seen in the table below.

Table 9-8 True results for Pipe bending

	February	March
On time	7	6
Total	15	12
Percentage	**46,7%**	**50,0%**

The last issue is related to the automatic collection of data. In order for data to be connected to the right Milestone the name of the operations must be reported with the same name. For February and March 3 and 16 orders respectively were ignored by the measuring system. These orders were not called exactly 'Pipebending' as they were supposed to and for this reason the measurement system could not recognize them. These orders significantly affect the results of the measurement as could be seen below.

Table 9-9 Added missed orders

	February	March
On time	9	18
Total	18	28
Percentage	**50,0 %**	**64,3 %**

Welding, Assembly and Wiring

Since the problems of these Milestones are the same, they are presented together.

Issues

- Reporting of rework
- Non-exact data (also valid for pipe bending, test and packing)
- Reporting upgrades
- Calling the operations in different ways

The first problem has already been taken care of during the first months of this year, but the effects of the changes were not yet available when this report was written.

The second problem is related to the fact that the measurement system is counting orders reported ready within a span of three days from the planned as on time. This is seriously affecting the validity of the results for these Milestones especially when considering that the a machine are supposed to spend five days, neither more or less, in the assembly line, and only one day in welding. The operators have to be made aware of the importance of having credible data in the system in order to help the organization to determine areas of improvement. Thus they should consistently report the operations on the correct day, eliminating the need for these three extra days.

The third bullet deals with the issue that upgrades are not handled in the manually collected Milestones, but sometimes affect the result of the workshop Milestones. The intention is to include upgrades throughout the system, but at the moment it is giving a biased picture on process performance.

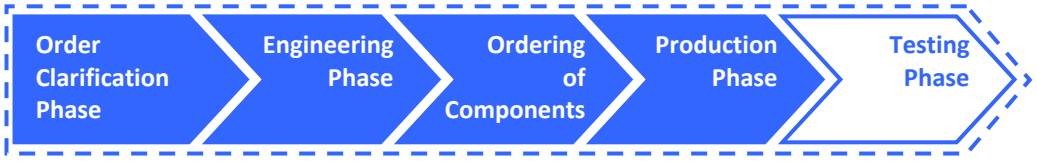
The last issue is treated in 'Pipe bending' above. The orders that were not recognized by the measurement system from January 2008 and January 2009 are distributed as follows:

Table 9-10 The number of orders not counted for Assembly, Welding and Wiring respectively.

Operations	Total orders	Orders not recognize by the measurement system	Percentage
Assembly	603	25	4,15%
Welding	256	12	4,69%
Wiring	562	25	4,45%

As seen in the table these orders do not represent any major part of the total but they still influence the results. The problem should according to our sources recently have been solved with the creation of the new work centres. From now on the operations are going to be measured by work centres instead of by operation name.

9.10.5 Testing phase



Test and packing

Issues

- Non-exact data/ Test operators cannot report the activities by themselves
- Reporting upgrades
- Reporting orders from another production plant – Cold plant (Packing only)

The first problem is the exact the same problem presented for 'Assembly', 'Welding' and 'Wiring' with the three extra days that are included in the measurement. The TRs cannot report the finishing of the tests themselves and must have the responsible OP do it.

The second issue was also presented in the previous analysis off 'Assembly', 'Welding' and 'Wiring'.

The third problem is only present for 'Packing'. The measuring of this Milestone has also included orders from 'Cold plant'. As shown in the empirical data, these orders have a significant impact on the results of the 'Packing Milestone' since they represent more than 20 % of the orders handled during this the period January 2008 to January 2009. Considering the results in the table below the impact is further of a negative kind.

Table 9-11 Performance of Cold plant

	Number of orders	Percentage of the total
On time	24	21,8%
Late	86	78,2%

The effect on the 'Packing Milestone' can be seen in the following table.

Table 9-12 The negative effect of cold plant on the Packing Milestone

	Number of orders	On time	Late
Packing Milestone	729	63,6%	36,4%
Packing Milestone without Cold plant	619	71,1%	28,9%

As seen in the table the average result is significantly increased when the Cold plant orders are removed. The recommendation is thus that these orders should be removed from the input data, since they obviously do not belong.

9.10.6 Other Milestones

Fulfilment of customer request and Orders with dates entered

Issues

- Missing data
- Misleading name
- No apparent relevancy ('Orders with dates entered')

'Orders with dates entered' indicates that more than 35 % of the orders as missing information for 'Fulfilment of customer request' for the period between January 2008 and January 2009. Once again this influences the credibility of the Milestone.

The second problem is related to the basic design of the measure. Basic customer orientation tells us that the customer needs are important, and a measure taking this into consideration seems like a good idea. However, the 'Fulfilment of customer request' is not focusing on the customer needs, but only on internal planning. We would thus recommend a new name for it to better illustrate the measure's purpose. A suggestion would be 'Planned to meet customer request'.

Further proof of the weaknesses with the current name is illustrated by the table below. It shows the 25 orders that were measured as late according to the 'Delivery Accuracy Milestone' during the period January 2008 to January 2009.

Table 9-13 Late orders fulfilling customer request

	Number of orders	Percentage of the total
Fulfilled the customer request	12	48,0%
Did not fulfil the customer request	2	8,0%
Without dates entered	11	44,0%

Of the 25 orders that were late according to 'Delivery accuracy', 12 were considered to have fulfilled the customer request. It is hard to imagine a situation were a machine is delivered late and still fulfils the customers request on delivery date. As for right now it is enough to plan to fulfil the customer request in order to get a good score on this measure.

The third remark is directed at the 'Orders with dates entered Milestone'. The name is confusing since it only relates back to the 'Fulfilment of customer request', and the motivation behind including an additional measure of this type only for the 'Fulfilment of customer request Milestone' is vague. BU DBF should choose to either include this type of measurement for all the Milestones or for none.

Delivery Accuracy – R/3

Issues

- Irrelevant

The 'Delivery Accuracy – R/3 Milestone" is at the moment largely irrelevant. Unless the process is working in a way where the 'Planned dispatch date' and the 'Actual dispatch date' are reliable performance indicators, this measure should be excluded from the reporting. In the longer run, the automatic measuring of the delivery accuracy is something to strive for, but at the moment there are too many exceptions from process specifications and directives.

One reason to keep the Milestone could be to indicate how far from the perfect state the current process is. This could perhaps be a good idea, but then the Milestones should be placed beside each other, and clear indication on how the results should be interpreted must also be presented.

Delivery accuracy

Issues

- 'Delivery accuracy' does not compare the same days as 'Delivery Accuracy - R/3'
- Based on opinions rather than objective facts.

When introducing this issue in the empirical part, it was shown that the results for this Milestone would look a lot worse if it compared the same dates as 'Delivery Accuracy - R/3' does. The results, before reviewing the orders, were that 53 % were on time in the time period January 2008 to January 2009. Using the same dates as used for 'Delivery _Accuracy - R/3' the result would be reduced to 33 %.

The second issue weakens the objectivity of the Milestone, as the results are based on the opinions of the people that work in the process. The ORO can choose among multiple reasons to why an order that was late according to 'Delivery Accuracy - R/3' should be considered to be on time. Every evaluation including any kind of opinion should be avoided if possible.

If we take a closer look at the orders for which 'Delivery accuracy' was calculated for the months between January 2008 and January 2009 we can see that before reviewing these

orders there were 244 orders delivered late, which represent 47 % of the total. The Ores reviewed these orders and reported the reasons for the delay. The possible reasons for the delays were presented before, and are repeated in the table below. If the reason for a delay is of the types 1-7 then it is considered on time, otherwise it is considered late. Type 0 could be called "Other" and these reasons were approved by the Quality Manager.

Table 9-14 Possible reasons for delay

Reasons for having an order late.	
1	Goods ready but waiting for shipping instructions
2	Goods ready but waiting for inspection ordered by MC
3	Dispatch delayed due to variation order (dispatch date should have been changed but was not)
4	Goods issue missed with one or two days, but the planned and agreed transport kept
5	Goods ready but awaiting coordinated delivery of many orders to the same customer
6	Goods ready for dispatch but put on hold on request from MC
7	Reporting in R3
8	Problems in supply chain
9	OFCE - Design or specification
10	Lack of resources in OFCE
11	Ind. - Problems in specification industrialized product
12	Customer Management - Problems in sales order (customer understanding)

After all the 244 orders delivered late were reviewed by the responsible ORO only 25 (10.2 %) were still considered as late. The remaining 219 (89.8 %) were thus changed from late to on time. These 219 orders were distributed among the reasons as is presented in the table below:

Table 9-15 The distribution of the orders that where changed to being considered in time.

	0	1	2	3	4	5	6	7	Total
Number of orders	4	29	7	5	50	61	17	46	**219**
Percentage	2 %	13 %	3 %	2 %	23 %	28 %	8 %	21 %	

From the table above we can see that the main reasons stated by the ORO's to explain why an order should be considered as on time are those with number 4 and 5 respectively, whom together represent 51 % of the orders. Reason 4 states that the goods issue was missed by one or two days but the planned and the agreed transport were kept. This means that the shipping was reported late, but that the activities were performed in time.

Reason 5 says that the goods were ready on time but were to be included in a coordinated delivery of many orders to the same customer, and thus had to wait. Since BU DBF base their production planning on delivery dates, machines with earlier delivery dates tend to be planned before machine with later delivery dates. When a machine has to wait to be co-delivered with other machines, this might have resulted in a non-optimal prioritization in production. Giving priority in the production workshop to a product that is going to be delivered later than expected is most likely resulting in longer delivery time for other

products, and possible excessive use of resources. A less grave, but still tangible problem with orders waiting to be co-delivered is the fact that they take up storage space and are binding capital.

The overall responsibility for this issue lies with the MCs. Since they, when ordering several machines in a line, treat Tetra Pak's companies/BU as different suppliers they are at the moment not considering the fact that they could be co-delivered. Whenever ordering multiple machines from the same BU/Company or multiple machines from the same site (e.g. Lund) the MC should inform the latest delivery date to all involved so that the internal planning could be based on this. The responsibility must lie with the MCs since they are the only ones that know from the start which orders should be co-delivered. To get them to realize their responsibility a fee should be charged for storing the products that is high enough to make a difference. Since the money is transferred within Tetra Pak, this does not affect the companies overall result.

Another interesting reason is reason 1 which has a total of 29 orders (13 % of total cases) during the relevant thirteen months. The fact that the goods were ready but were waiting for shipping instructions clearly states that there is a problem in the process. The shipping instructions should be filled in the order form, and thus be retrieved at the same time as the order is received. It might appear as a minor detail to have the shipping instructions, but it boils down to a fundamental question that affects the whole process, namely the clarity of an order. Should an order be accepted and started when all the information needed is received or when all the required information is received? Obviously, on the 29 mentioned occasions the formed was the case. If an order is accepted without shipping instructions, it should be up to the SSM or the ORO to obtain it before the delivery day. If the MC fails to provide it despite several reminders, a storage fee covering handling costs and the cost of capital should be added to the price. A feature that would automatically remind the ORO when the order is missing the shipping address could help to solve this problem.

9.11 Appendix K – Example of interview guide

Interview Questions for OFCE Managers

This document contains the questions intended to be posed to the OFCE managers. They are based on the problem areas that are presented in the main report.

The order process

- Can you in short explain how the order processing is conducted here? Which are the key activities of the process?
- Have you standardized your procedures/'way of working'? If yes, how do you make sure that the standards are followed?
- How are new employees introduced to the process?
- When do you transfer the order to another department?
- Are there any deviations in the 'practice' compared to the documented process in POINT that you are aware of?
- How many orders is one person typically working with at the same time?
- What methods are used for prioritizing among the orders, using: FIFO (First In First Out), based on the delivery time, the customers importance etc.
- How many people are typically involved with working with an order?
- How many people, with each different role, are currently working here?
- Do you have ideas of how the current process might be improved? Who would you turn to in the normal case with such suggestions?

The measurement system

- Who enters the dates into the measuring system? Is there any control of if these are correct?

- How great is the distance (measured in days) from the receiving of an order to each Milestone (within the part of the process that you are responsible for)? Do the Milestones differ between orders/products? How are they decided up on?

- How important are good results on measurements compared to other tasks/matters in your work?

- Do you think that the "New Milestones" are good indicators on process performance? Would you consider 100 % accuracy as an indication of performance excellence?

- Do you think the system measures what it is intended to (consider the whole OFCE-process)?

- Why do you think data sometimes are missing?

- Do you think that the "New Milestones" are good indicators on process performance in the part that you are responsible for? / Do you think it measures what it is intended to?

- Does the measurement system help you in your daily work?

- Do you think there are any problems/deficiencies with the measuring system?

- Does the system give any direction on how to improve the process?

- Do you have any suggestions on how the measuring system could be improved?

The delays

- What are, as you see it, the main problems of the order process?

- What are, as you see it, the main problems of the order process that you are responsible for?

- Which are the main causes of the most frequent delays, as you see it?

- Which are the causes behind the biggest delays (in terms of time)?

- Do you document the causes of delay in any way?

- How do you work with the follow up of delays / improving your way of working?